POWER

Vol. 45 NEW YORK, APRIL 10, 1917 No. 15

An Interested Spectator

Energy Stored in a Boiler Under Pressure

By F. R. Low

The article describes how the energy which would be released by an exploding boiler per pound of contained water and steam is computed. There seem to be two schools of thought upon the subject and twenty-odd of the leading authorities divide themselves quite evenly between them.

How much energy is stored in a boiler under pressure? Of course it depends upon the weight of steam and of water which the boiler contains and their temperature and pressure, but how much energy is stored per pound of water and of steam at a given temperature and pressure? How much energy available for destruction or disturbance is released per pound of water and of steam when a boiler explodes at a given pressure? If you were making a table of the energy stored in boilers for use before legislative committees as showing the potency for harm of these magazines of energy and how they compared with other explosives, what values would you use?

Imagine a pound of water heated to 338.1 deg. F. in a nonconducting cylinder and retained under 115 lb. per sq.in. absolute (about 100 lb. gage) pressure by a diaphragm, as in Fig. 1. Suppose the diaphragm to burst. When the pressure was released, the steam and the air in front of it would be shot upward with some velocity.

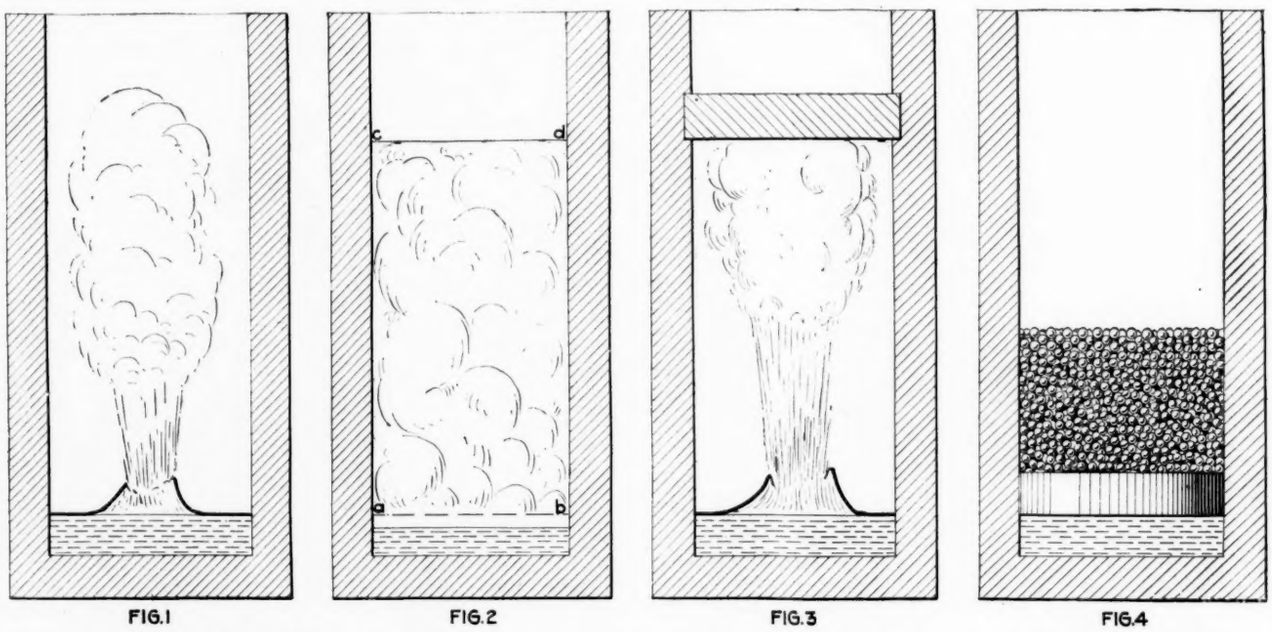


FIG.1 FIG.2 FIG.3 FIG.4

FIGS. 1 TO 4. ILLUSTRATING DIFFERENT METHODS OF CHANGE OF WATER FROM 115 LB. AND 338 DEG. TO ATMOSPHERIC PRESSURE AND 212 DEG.

In Fig. 5 let vertical distances represent absolute temperatures, and areas quantities of heat. For example, starting with a pound of water at 32 deg., lay off to any convenient scale the line OA, $32 + 460 = 492$ units long, OB, $212 + 460 = 672$ units long, and OC, $338.1 + 460 = 798.1$ units long. From B lay off BD of such length that the area $ADEOA$ under the curve AD will represent, to any convenient scale, the amount of heat (180 B.t.u.) necessary to raise the pound of water from 32 to 212 deg. The line BD is proportional to the entropy of the liquid at 212 deg., the value of which may be found in the steam tables, and by plotting these values against a sufficient number of corresponding temperatures the curve may be laid out accurately; but this is not necessary for the present purpose. The thing to bear in mind now is that the area $ADEOA$ represents the 180 B.t.u. necessary to raise the pound of water from 32 to 212 deg.

Continuing the application of heat, the temperature rises to 338.1 and the pressure to 115 lb. absolute, and the amount of additional heat required to do this is proportional to the area $DFGED$, CF being proportional to the entropy of the liquid at 338.1 deg. The whole area of the diagram $AFGOA$ is proportional to the amount of heat (309 B.t.u.) necessary to raise a pound of water from 32 to 338.1 deg.

When the pressure on the water is reduced to that of the atmosphere (14.7 lb.), its temperature will drop to 212 deg., and to heat it to 212 deg. requires only the amount of heat represented by the area $ADEOA$. That represented by the area $DFGED$ is available for doing something else. What does it do?

Notice that in making this diagram the addition of heat is indicated by a movement to the right, in the direction of greater entropy. The subtraction of heat would be indicated by a movement to the left, or a diminution of entropy. But a drop from a higher to a lower temperature with neither gain nor loss of heat would be represented by a vertical line, or a line of constant entropy. If, then, the temperature of the pound of water changes from 338.1 to 212 deg. without giving up any of its heat as heat to the surroundings and without acquiring any heat from anywhere, the change of state would be represented on the diagram by the line FJ.

The entire pound of matter with which we started is now at 212 deg., although some of it is water and some is steam. Therefore all the heat now in the mixture must

be represented in that part of the diagram below the 212-deg. line *BJ;* and since the entropy has remained constant, it must be represented in the diagram bounded on the right by the line *JG*. The heat which would be required to convert a pound of water at 32 deg. to a pound of the mixture of steam and water, which would result from the assumed change of pressure, is then represented by the diagram *ADJGOA*, and the amount represented by the triangle *DFJ* will have been set free as mechanical energy and is available to effect disturbance and possible destruction.

The whole diagram *AFGOA* represents the heat h_1 necessary to raise the temperature of a pound of water from 32 deg. to 338.1 deg. This can be found from the steam tables to be 309 B.t.u. The area *ADEOA* represents the heat h_2 necessary to raise a pound of water from 32 to 212 deg. If this value and the value in heat units of the rectangle *DJGED* be subtracted from 309, the remainder will be the value of the triangle *DFJ;* that is, the number of B.t.u. converted into mechanical energy.

The total width *BJ* of the diagram is proportional to the entropy n_1 of the water at 338.1 deg.; the distance *BD* to the entropy n_2 of the water at 212 deg. The width *DJ* of the rectangle whose value we seek is, therefore, $n_1 - n_2$. Its height is proportional to the absolute temperature $T_2 = 212 + 460 = 672$. Its area (width $\times$ height) is therefore proportional to the difference of the entropies times the absolute temperature, or $(n_1 - n_2)\ T_2$. Calling the heat in the initial state (309 B.t.u.) h_1, the heat U converted into mechanical energy (represented by the triangle *DFJ*) will be as follows:

$$\underset{10.8}{U} = \underset{309}{h_1} - \underset{180}{h_2} - \underset{(0.4877 - 0.3118)\ 672}{(n_1 - n_2)\ T_2}$$

This would indicate that the heat equivalent of the energy released by a pound of water at 338.1 deg. when the pressure upon it was reduced from 115 lb. absolute to that of the atmosphere was 10.8 B.t.u.

Should the Work of Displacing the Atmosphere Be Included?

Now this does not include the work that was done upon the atmosphere in making room for the steam. If the steam did not condense, but remained as steam at 212 deg. and settled back into the cylinder, we should have the condition represented by Fig. 2, where the evaporation of a part of the water has lifted the atmosphere from the level *ab* to the level *cd*. The work done (and this is true, of course, whatever becomes of the steam after it is made) is the product of the atmospheric pressure and the difference between the volume of the original water and the final volume of water and steam. If the volumes are taken in cubic feet and the pressure in pounds per square foot, the energy will be in foot-pounds and this divided by the mechanical equivalent in foot-pounds of a B.t.u. will be the number of heat units involved. Dividing by the mechanical equivalent is the same as multiplying by its reciprocal, and this reciprocal is denoted in books on thermodynamics by *A*. The pressure per square foot is called *p*, the difference in volume *u;* and this external work, which is done in forcing back the environment when water changes into steam, is called the *Apu* work, being the product $A \times p \times u$.

The latent heat, the heat required to evaporate water into steam, does two things. Some of it does this *Apu* work of pushing back the atmosphere or the other steam into which the newly generated steam emerges, and the rest does the work of separating the molecules of the water and is represented in the potential energy of the separation of their centers of gravity. This is called the internal energy of evaporation and is given in the steam tables under the symbol *I*. The latent heat of evaporation *L* is therefore the sum of the internal and external heats of evaporation, or $L = I + Apu$.

If the pressure upon the pound of water in the first place had been that of the atmosphere instead of 115 lb. absolute, when the temperature reached 212 deg. it would have commenced to boil and the temperature would have gone no higher, but the increase of heat would have continued along the line of equal temperature (212 deg.) *DH*. When the whole pound of water had been converted into steam, the line *DH* would be of such length that the area

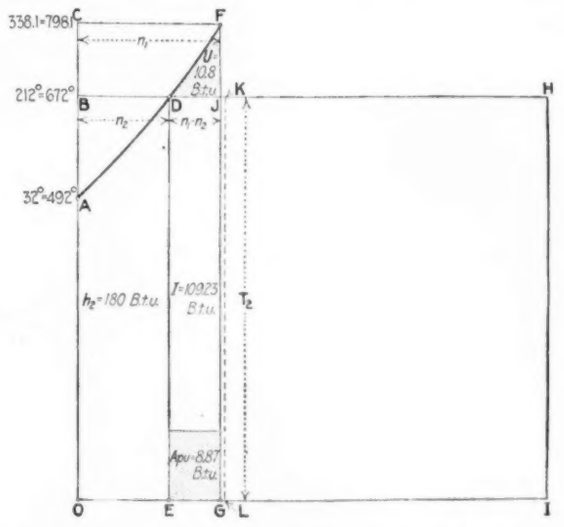


FIG. 5. TEMPERATURE ENTROPY DIAGRAM FOR WATER BETWEEN 338 AND 212 DEG. F.

DHIED under it would be proportional to the amount of heat required to evaporate a pound of water at 212 deg. into steam of the same temperature.

Of the amount of heat still in the steam and water (that represented by the diagram *ADJGOA*) the portion represented by *ADEOA* was required to raise the temperature to 212 deg. That represented by the rectangle *DJGED* is available for evaporation. If it takes an amount proportional to the area *DHIED* to evaporate the whole pound, the fraction of a pound evaporated by the heat represented by the smaller area would be represented by the proportion of those areas, or, since they are of the same height, by the ratio of their widths. In this case the fraction of the pound of water that had been evaporated into steam would be $\frac{DJ}{DH}$.

Now $DJ = n_1 - n_2$ and $DH =$ the entropy of evaporation; or since it is one side of an area proportional to the latent heat *L* and having the height *T*, it is equivalent to $\frac{L}{T}$ and is so designated in the steam tables. The proportion of steam in the mixture is called *x*. So we have

$$x_2 = \frac{n_1 - n_2}{\frac{L_2}{T_2}} = \frac{0.4877 - 0.3118}{1.4447} = 0.1217$$

We have seen that the latent heat L is the sum of the internal heat of evaporation I and the Apu work; then

$$Apu = L - I$$

From the steam tables it is found that for 212 deg. $L = 970.4$ and $I = 897.5$; then

$$Apu = 970.4 - 897.5 = 72.9 \text{ B.t.u.}$$

This would be the number of B.t.u. required to push back the environment to make room for the change of a pound of water into steam at 212 deg. For 0.1217 lb. there would be required

$$0.1217 \times 72.9 = 8.87 \text{ B.t.u.}$$

Should this Apu work be included? Is the energy released by a pound of water under the assumed conditions 10.9 B.t.u. or 10.9 + 8.87 = 19.77 B.t.u.?

If it were asked simply, "How much external energy is exerted by a pound of water—etc.?" there would be no doubt that it would be the higher value. There is no doubt that the Apu work is exerted upon the envelopment, but pushing the atmosphere back is *all* that it can do. Having done that, it is locked up in the potential energy of the displaced atmosphere, and any damage that is caused or any disturbance that is produced must be at the expense of other B.t.u.'s. If walls are blown down, windows broken, blasts produced by this forcing back of the surrounding air, these effects are all extraneous to the Apu work, which simply means the generation of a certain volume against the atmospheric pressure. As the energy *released,* and available for damage or at least disturbance, is what is wanted, it would appear from this view of the case that it is the lower value, or 10.8 B.t.u.

It makes a difference, therefore, how the case is stated—how the inquiry is framed. When the question arose in the course of our editorial work, we found such disagreement among authorities that we asked a score or more of authorities what the value would be for 115 lb. absolute and 212 degrees. The form of the letter and the values received in reply are given on page 477 and it will be seen that they are about equally divided between the high and low values, indicating a wide difference in thought and teaching upon a question which the legislative or working world is likely to ask of the professional any day.

If it were asked of you, what would your answer be?

Expansion Without Doing External Work

Suppose that the cylinder, instead of being open as in Fig. 1, were closed at the top with a partition, as in Fig. 3, the space between the partition and the diaphragm retaining the water being vacuous. When the diaphragm broke, a mass of steam and water would be projected against the partition. But the partition and the containing wall are assumed to be nonabsorptive and impervious to heat. They will not let any of the heat out nor absorb any of it. Therefore the heat represented by the kinetic energy, the energy of motion, of the projected mass is reconverted, by impact and eddying and friction, into heat and is applied to evaporating more of the water than as though it went off in the energy of flying masses. In this case we have in the pound of water at 115 lb. 309 B.t.u., in the pound of mixture of steam and water at 212 deg. 180 B.t.u., and since none of it could get away, all the rest is available for evaporating water. The quality, or the fraction of the pound evaporated, would be

$$\frac{h_1 - h_2}{L} = \frac{309 - 180}{970.4} = 0.132$$

In this instance the kinetic energy represented by U in Fig. 5 may be conceived as having been reconverted to heat and added to the diagram at $JKLGJ$, which area is equal to that at DFJ. The volume under the partition must of course be that of 0.132 of a pound of steam and 0.868 of a pound of water, both at 212 deg.

Expansion While Doing External Work

Or imagine a frictionless and weightless but still nonconducting piston over the liquid, as in Fig. 4, and assume the piston to be loaded with 100 pounds of shot per square inch of its area, exerting upon the water the combined pressure of the shot and the atmosphere (115 lb. per sq.in.) and allowing it to be heated to 338.1 deg. without boiling. If, now, some of the shot is removed, the pressure will become less, the water will boil until by

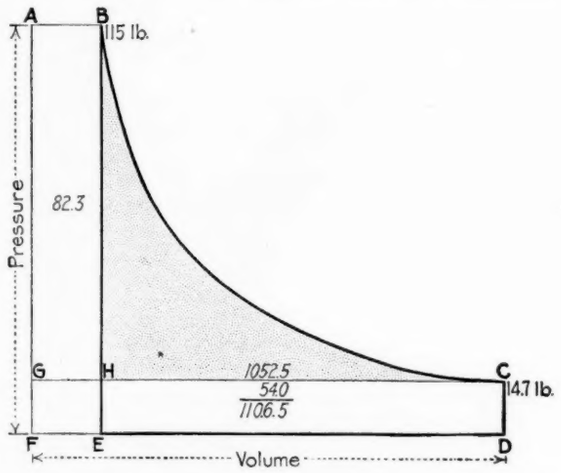


FIG. 6. PRESSURE-VOLUME DIAGRAM FOR STEAM BETWEEN 115 AND 14.7 LB. ABSOLUTE

evaporation its temperature is reduced to the boiling point under the new pressure; and when the shot is all removed, there will be only the atmospheric pressure upon the mixture, and the temperature will be 212 deg., as in the preceding case. Of the 309 B.t.u. in the pound of water at 115 lb., 180 are in the mixture of steam and water at 212 deg., 8.87 are represented by the work of raising the piston *against the atmospheric pressure,* 109.23 in making a part of the water into steam and 10.9 in lifting shot, for each lot of shot was taken off at a higher level than the previous one. Is the 8.87 B.t.u. used to push back the atmosphere to be credited to the effective work of the steam?

It is probable that in a boiler explosion some of the energy is reconverted to heat and some of the heat is absorbed by the environment. It is not necessary to complicate this discussion with a consideration of the probable extent and effect of these interchanges. It will be enough if we can come to an agreement about the abstract case where the change of state is assumed to occur at constant entropy.

We tried to throw out a hint as to the point involved by asking in the final paragraph,

> Do you agree that the energy so exerted per pound of contained steam would be expressed by the difference between the internal energies at 115 lb. and at 212 deg.?

Imagine a pound of steam at 115 lb. to change places with an equal volume of free atmosphere. All that it can do is to expand, to generate energy equivalent to the portion of the pressure-volume diagram, Fig. 6, beneath the

expansion line; the area *BCDEB*. The energy represented by *ABEFA* was generated when the steam was made and is developed during the admission of this pound of steam into an engine cylinder or turbine nozzle by the simultaneous generation of an equal volume of steam in the boiler, pushing this one out; otherwise the pressure would not remain constant. A pound of steam changing places with an equal volume of free atmosphere can do none of this work; it can simply expand, and if the expansion is adiabatic or isentropic (that is, without the gain or loss of heat), the heat accounted for will be the same in the initial and final conditions.

The internal heat (that is, the difference between the total heat and the heat equivalent of the *Apu* work) is given in the tables under the designation *E*, and since the action is by definition to take place without gain or loss of heat, the difference between these internal or intrinsic heat energies before and after expansion will be the heat equivalent of the work performed; that is, of the area *BCDEB* of Fig. 6. For a pound of dry-saturated steam at 115 lb., this is given by the table as 1106.5 B.t.u. After expansion, if it were still all steam, we could take the tabular value of *E* at the lower value away from 1106.5 and find the heat available for performing work. But during expansion a part of the steam will have condensed and the quality and consequent internal energy will have to be computed.

The difference between the internal, or inherent, energies in the initial and final conditions, x_2 in this case being 0.885, is

$$E_1 - E_2 = 1106.5 - 974.34 = 132.16 \ B.t.u.$$

This is represented in Fig. 6 by the area *BCDEB*. We asked if the person addressed agreed that the energy *released* (that is, available to produce disaster and disturbance) is that represented by this whole area or whether it should be reduced by taking out that represented by the area *HCDEH* (that is, the energy absorbed in pushing back the atmosphere with a pressure proportional to *CD* through a volume proportional to *ED*); in other words, whether for the case of the steam the energy available for damage and disturbance should be taken as that represented by the area *BCDEB* or by the shaded area *BCH*.

A Large Flume Condenser

By B. S. Nelson

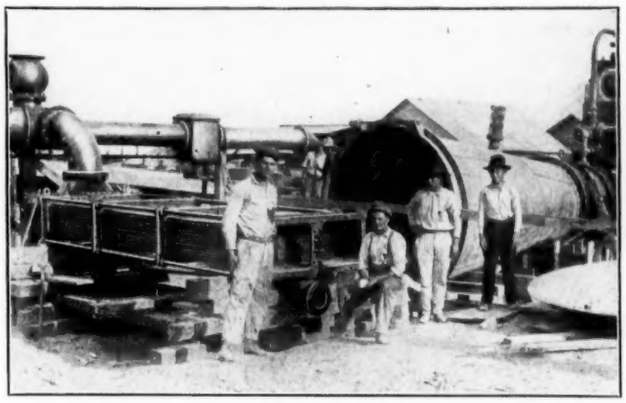
To an engineer familiar with surface-condenser practice the statement that a certain condenser had its cooling water supplied by a 60-in. centrifugal pump would bring visions of a power plant of giant proportions, and if he were further advised that this condenser was designed to condense the exhaust from a 1000-hp. engine, he would probably wildly reach for his slide rule to calculate the steam rate of that engine.

The illustration shows the condenser referred to, which was designed and built by me, and is installed in an irrigation plant on the Rio Grande River, near Pharr, Tex. Probably some of the recently returned members of the National Guard who were stationed there will remember having seen this plant.

This type of unit, called the flume condenser, is popular on the Rio Grande because of its simplicity and low first cost and because it requires one less pump than the ordinary surface condenser. As the temperature of the cooling water is high, this means a saving in first cost and in the operation of a comparatively large pump.

This particular condenser, which is one of three duplicates built for the same company, has 1400 sq.ft. of cooling surface and handles the exhaust from a 20&42x42 slow-speed engine. The condenser is set in the discharge pipe in front of the flap valve on the end of the discharge pipe; the illustration shows the unit in place ready for the concrete discharge pipe to be built around it.

The condenser consists essentially of two cast-iron boxes, heavily ribbed and open on opposite sides. On one side are bolted the brass tube sheets, and on the opposite side are removable cast-iron covers to permit access to the tubes and packing. The tube holes are machined to take standard ¾-in. condenser ferrules and



CONDENSER READY FOR CONCRETE DISCHARGE PIPE TO BE BUILT AROUND IT

corset-lace packing. The boxes are held apart the proper distance to take a 12-ft. brass tube, by four 2-in. distance rods. In this particular case the boxes are set in the concrete walls of the square discharge pipe, with the cover plates exposed, which makes the tubes easily accessible. Sometimes the condenser is set bodily in an open canal or flume, in which case the whole apparatus can be lifted out of the water for inspection or for the repair of tubes.

In order to prevent the tubes from vibrating and sagging, there are two steady plates consisting of heavy cypress boards through which the tubes pass with a close fit. The boards are held in position by the four distance rods at their corners, to which they are held square by set collars on the rods on each side of the board.

Steam is admitted to the box through a special fitting which connects to the box with a long narrow opening in order to distribute the steam over the ends of the tubes.

Sometimes these condensers are built with iron boiler tubes as cooling surface, in which case the tubes are expanded in steel or cast-iron tube sheets (the same as boiler tubes in a boiler), special care, however, being taken to provide for expansion and contraction. The iron-tube condenser is cheaper, but more bulky and naturally not so long-lived as that with brass tubes.

A Good Tin-Base Babbitt Metal for ordinary use is made of tin 90 per cent., copper 4 per cent., antimony 4 per cent., nickel 2 per cent. Melt the copper first in a crucible, then add the antimony and nickel, then lower the temperature a little and add the tin. Stir well before pouring and pour at a temperature that will char a pine stick.

Specifications for Motor Applications*

By A. G. Popcke†

SYNOPSIS—The principal points to be considered when specifying electric motors for industrial plants are discussed, with special reference to the characteristics of polyphase induction motors.

At the present, approximately three times as many alternating as direct-current motors are used in industrial work. The induction type is used almost universally for industrial service. These are of the squirrel-cage and wound-rotor types. In approximately 90 per cent. of the applications, squirrel-cage motors are used. This type is applicable where constant speeds are required and where the torque required at the start is not excessive. Wound-rotor motors are required where the starting torque is heavy. This type of motor is also necessary where speeds below the normal speed of the motor are required. The use of this type of motor is not equivalent to the adjustable-speed direct-current machine. On the wound-rotor alternating-current motor speeds are reduced below normal by inserting resistance in the rotor by means of a controller. The horsepower output decreases in direct proportion to the speed. Reduced speeds are only obtainable when the motor is loaded. On the direct-current adjustable-speed motor for a given adjustment the speed does not vary over 6 per cent. from light load to normal rated load.

An alternating-current motor is characterized by its horsepower, speed, phase, voltage and frequency. Only certain definite speeds are obtainable; this is dependent on the number of poles for which it is wound—that is, 2, 4, 6, 8, 10, 12, etc. Sixty-cycle motors operate at the following speeds:

No. of Poles	Motor Speeds — Rated Load	Motor Speeds — Synchronous or No Load
2	3,400	3,600
4	1,750	1,800
6	1,150	1,200
8	850	900
10	690	720
12	580	600

Twenty-five-cycle motors operate at the following speeds:

No. of Poles	Motor Speeds — Rated Load	Motor Speeds — Synchronous or No Load
2	1,450	1,500
4	720	750
6	480	500

Table I gives the combination of horsepower and speeds furnished by the majority of manufacturers for continuous-duty squirrel-cage and wound-rotor motors. The value of torque and square root of torque is given for each rating.

The difference between the no-load and full-load speed is called the slip, and is usually 5 to 7 per cent.

To conform with the voltage of the circuits available, alternating-current motors are supplied for 110, 220, 440 and 550 volts. Two- and three-phase motors are guaranteed to operate successfully on voltages 10 per cent. lower or higher than these; that is,

Motor Voltage	Allowable Line Voltage	Motor Voltage	Allowable Line Voltage
110	99 to 121	440	396 to 484
220	198 to 242	550	495 to 545

An increase in voltage will produce a slight increase in full-load speed; the no-load speed depends only on the frequency. A 10 per cent. increase in voltage will produce a 10 per cent. reduction in slip, or if a motor has 5 per cent. slip at normal voltage and on the other hand at 10 per cent. reduced voltage, the slip will be increased from 5 to 5.5 per cent.

The starting and maximum torques increase in direct proportion as the square of the voltage. Thus a 10 per cent. increase in voltage will produce a 21 per cent. increase in these torques and vice versa. A 10 per cent.

TABLE I. RATINGS OF SQUIRREL-CAGE AND WOUND-ROTOR INDUCTION MOTORS

The Values of Torque and Square Root of Torque Are Given for the Ratings Most Commonly Used

Poles		4		6		8		10		12		14	
Full Load Speed		1750		1150		850		690		580		495	
		T	$\sqrt{T}$	T	$\sqrt{T}$	T	$\sqrt{T}$	T	$\sqrt{T}$	T	$\sqrt{T}$	T	$\sqrt{T}$
Horsepower Rating	¼	0.7	0.8	1.1	1.1								
	½	1.4	1.2	2.2	1.5								
	¾	2.2	1.5	3.3	1.8								
	1	2.9	1.7	4.4	2.1								
	2	5.8	2.4	8.8	3	11.7	3.4						
	3	8.8	3	13.1	3.6	17.5	4.2						
	5	14.6	3.8	22	4.7	29.2	5.4	36.5	6	43.7	6.6	51	7.1
	7½	22	4.7	33	5.8	43.8	6.6	54.7	7.4	65.5	8.1	77	8.8
	10	29	5.4	44	6.6	58.4	7.8	73	8.6	87.5	9.4	102	10.1
	15	44	6.6	66	8.1	87.5	9.4	110	10.5	131	11.5	153	12.4
	20	58	7.6	88	9.4	117	10.8	146	12.1	175	13.2	204	14.3
	25	73	8.5	110	10.5	146	12.1	182	13.5	218	14.8	255	16
	30	88	9.4	131	11.5	175	13.2	219	14.8	262	16.2	307	17.5
	40	117	10.8	175	13.2	234	15.3	292	17.1	350	18.7	410	20.2
	50	146	12.1	219	14.8	292	17.1	365	19.1	437	20.9	510	22.5
	60	175	13.2	263	16.2	350	18.7	438	20.9	525	23	613	24.8
	75	219	14.8	329	18.1	437	20.9	547	23.4	655	25.6	766	27.7
	100	292	17.1	438	20.9	583	24.2	730	27	875	29.6	1,020	32
	125	365	19.1	546	23.4	730	27	915	30.3	1,090	33	1,280	35.8
	150	438	20.9	657	25.6	875	29.6	1,100	33.2	1,310	36.2	1,530	39.2
	200	584	24.2	875	29.6	1,170	34.2	1,460	38.2	1,750	42	2,040	45.2

reduction in voltage will enable a motor to produce only 81 per cent. of the torques at normal voltage.

An increase in voltage in general tends to better the performance (efficiency and power factor) and a decrease to decrease the performance. This, however, depends on the details of the design, as the relation of iron and copper losses.

As explained in the discussion of direct-current motors, voltages ranging more than 10 per cent. from normal are not often encountered, and if they are met with the cause of the greater variation should be explained, whether the source of power be from a central or from an isolated plant.

As in a direct-current motor, the efficiency is the relation of power output to power input. In addition to this, the power factor requires consideration on alternating-current motors. This is the relation of the $\frac{\text{watts input}}{\text{volts} \times \text{amperes input}}$. The effect of poor power factor on a system is to reduce the current carrying capacity of both the distributing system and the generating equipment. It is therefore important that the power factor be as high as possible.

The higher the efficiency, the lower the yearly power bills for operating a motor. The cost of power per year

*Excerpts from an article in the "American Machinist," Feb. 1 and Feb. 22, 1917.

†Industrial electrical engineer, Westinghouse Electric and Manufacturing Co.

(based on 3000-hours operation at a rate of 1c. per kw.-hr.), motor operating at full load, is

$$\frac{hp. \times 746 \times 0.01 \times 3000}{full\text{-}load\ efficiency} = \frac{22.38\ hp.}{full\text{-}load\ efficiency}$$

The figure of 1c. per kw.-hr. is used because on this basis the corresponding values at other rates of power can be easily computed.

For example, the difference in power cost of a 100-hp. motor having a full-load efficiency of 91 per cent. and one having a full-load efficiency of 90 per cent., power costing 2½c. per kw.-hr., is as follows:

Motor at 90 per cent. efficiency $\frac{22.38 \times 100}{0.90} \times 2.5$	= $6,210
Motor at 91 per cent. efficiency $\frac{22.38 \times 100}{0.91} \times 2.5$	= 6,140
Difference per year	$70

The selling price of a motor at 580 r.p.m. is $900 approximately. This saving per year is 7.7 per cent. of the cost of the motor, or the saving in power will pay for the cost of the motor in 13 years.

The following will show the importance of high efficiency even on a small motor that is operated continuously.

For example, comparing 5-hp. motors, 1750 r.p.m., with efficiencies of 86 and 87 per cent., cost of power 3c. per kw.-hr.:

Motor at 86 per cent. efficiency $\frac{22.38 \times 5}{0.86} \times 3$	= $390 per year
Motor at 87 per cent. efficiency $\frac{22.38 \times 5}{0.87} \times 3$	= 385 per year
Saving per year	$5

The selling price of the motor is $80. Saving is 6.3 per cent. of motor cost, or saving will pay for the motor in 16 years.

As was previously stated, the starting torque of an induction motor varies as the square of the voltage applied. At normal voltage the starting torque of a squirrel-cage induction motor is as follows:

2-, 4- and 6-pole motors	150 to 175 per cent. full-load torque
8-, 10- and 12-pole motors	125 to 150 per cent. full-load torque
14-pole motors	100 to 125 per cent. full-load torque

It is nearly universal practice to start motors up to 5 hp. at normal voltage. In large sizes, 7½ hp. and above, the motors are started on decreased voltage to reduce the amount of current consumed while starting. Provision for obtaining 50, 65 and 80 per cent. of line voltage is made on commercial starting devices; 65 per cent. is generally used. Where the starting conditions are light 50 per cent. is sufficient, and 80 per cent. must be used where the starting conditions are heavy. At these reduced voltages the starting torques are as follows:

No. of Poles	At Normal Voltage	At 80 Per Cent. Normal Voltage	At 65 Per Cent. Normal Voltage	At 50 Per Cent. Normal Voltage
2, 4, 6	150 to 175	95 to 110	63 to 74	38 to 44
8, 10, 12	125 to 150	80 to 95	53 to 63	31 to 38
14	100 to 125	64 to 80	42 to 53	25 to 31

TABLE II. RATINGS OF INTERMITTENT WOUND-ROTOR MOTORS, VALUES OF TORQUE AT RATED LOAD AND MAXIMUM TORQUE ARE GIVEN

	Poles	4		6		8		10		12	
	Full Load Speed	1,750		1,150		850		690		580	
		Rated Torque	Max. Torque	Rated Torque	Max. Torque	Rated Torque	Max. Torque	Rated Torque	Max. Torque	Rated Torque	Max. Torque
Hp. on ½-Hr. Basis	2	....	..	8.8	18						
	3	8.8	18	13.1	26						
	5	14.6	29	22	44						
	7½	....	..	33	66	43.8	88	54.7	110		
	10	....	..	44	88	58.4	117	73	146		
	15	....	..	66	132	87.5	175	110	220		
	20	....	..	88	176	117	234	146	292		
	25	....	..	110	220	146	292	182	364		
	30	....	..	....	...	175	350	219	438	262	524
	35	....	..	....	...	204	408	255	510	306	612
	50	....	..	....	...	292	584	365	730	437	874
	75	....	..	....	...	437	874	547	1,094	655	1,310
	100	....	..	....	...	....	...	730	1,460	875	1,750
	150	....	..	....	...	....	...	1,100	2,200	1,310	2,620
	200	....	..	....	...	....	...	1,460	2,920	1,750	3,500

The National Electric Light Association has recently established permissible starting currents for squirrel-cage induction motors. These values, which represent the average obtained with motors of various manufacture, are given in Fig. 1; they also indicate that for starting torques greater than 80 to 100 per cent. the squirrel-cage induction motor cannot be used, unless the starting current is limited to the values given in Fig. 1. By starting the motor at normal voltage 125 to 200 per cent. starting torque is produced, but the heavy starting current of 8 to 10 times full-load current is usually not permissible nor desirable. In addition to straining the electrical apparatus, the jolt while starting under these conditions may result in mechanical injury to the machinery driven.

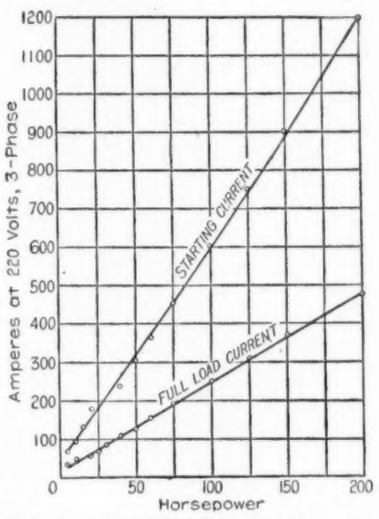


FIG. 1. CURRENT DIAGRAMS FOR SQUIRREL-CAGE MOTORS

In the case of wound-rotor motors, the starting torque depends on the amount of resistance inserted in the rotor windings. Full-load starting torque can be produced with full-load current. With this type of motor it is possible to obtain a starting torque equal to 2 to 2.5 times full-load torque on 2 to 2.5 times full-load current, by inserting the proper resistance in the rotor.

For this reason wound-rotor motors should be used where it is desirable to keep the starting current to a minimum, especially where starting conditions require a heavy starting torque.

For heavy starting duty, manufacturers also supply a special squirrel-cage motor. The standard squirrel-cage motor is fundamentally a constant-speed machine (speed only varies 4 to 6 per cent. from no load to full load). Its design can be modified, so that its operation is similar to that of the direct-current compound-wound machines. This modification consists of an increase of rotor resistance, having the effect of increasing the starting torque and decreasing the starting current at the expense of speed regulation. Greater slip is produced, the efficiency is lowered and heating is increased. On these motors the starting torque is 35 to 50 per cent. greater than that given for standard motors. The starting current is approximately 15 per cent. less. The maximum torque remains the same as the standard motor (2.5 to 3 times full-load torque). The slip is approximately 8 to 12 per cent., or twice that of the normal motor. The efficiency is approximately 3 to 5 per cent. lower than that for the standard motor, the power factor remaining

the same. This special squirrel-cage motor should only be used where the load is intermittent. In applications where starting conditions are heavy, but the load is continuous after it has been started, a wound-rotor motor should be employed as a more economical method of drive is thereby produced.

In addition to supplying wound-rotor motors for continuous duty they are furnished for intermittent duty. They are designed to produce heavy starting torque. The starting and maximum torque obtainable on these motors is twice the rated torque, the rated torque being based on a ½-hr. intermittent rating. This type of motor is used largely on cranes and hoists. The ratings are shown in Table II, which gives the values of both rated intermittent torque and maximum torque, which is the same as the maximum starting torque obtainable.

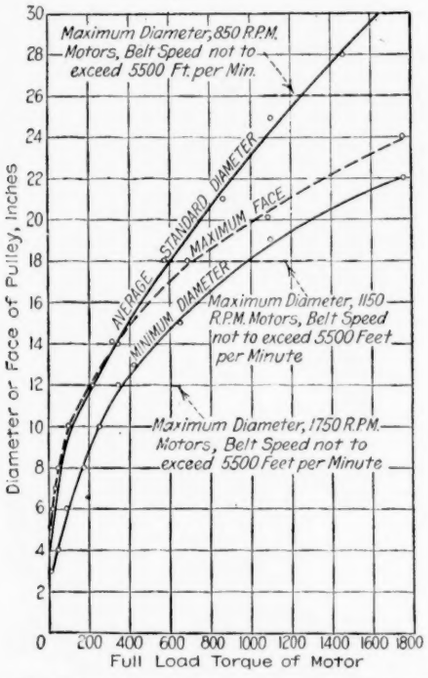

Maximum Diameter, 850 R.P.M. Motors, Belt Speed not to exceed 5500 Ft. per Min.
AVERAGE STANDARD DIAMETER
MAXIMUM FACE
MINIMUM DIAMETER
Maximum Diameter, 1150 R.P.M. Motors, Belt Speed not to exceed 5500 Feet per Minute
Maximum Diameter, 1750 R.P.M. Motors, Belt Speed not to exceed 5500 Feet per Minute
Diameter or Face of Pulley, Inches
Full Load Torque of Motor
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
0 200 400 600 800 1000 1200 1400 1600 1800

FIG. 2. RELATION OF MOTOR TO PULLEY DIMENSIONS

Motors are supplied for belted, geared, chain or direct-coupled drive.

For belted drive, manufacturers supply a pulley and also a sliding base with which to adjust the belt tension. In Fig. 2 is shown the limitations of the motor pulleys supplied. The curves show the relation between the average standard pulleys supplied and the rated full-load torque of the motors as given in Table I. The maximum face is limited by the length of shaft extension. The belt pull and, hence, the bearing stress due to belt pull on the motor bearing, increases as the size of the pulley decreases. For this reason there is a minimum diameter pulley for successful operation. Moreover, as the diameter of the pulley is reduced the belt slip increases.

Fig. 2 shows the minimum size pulleys recommended for various sizes of motors. An example will best illustrate the use of these curves. To determine the pulley limitations for a 50-hp. 850-r.p.m. motor, refer to Table I. The full-load torque of a 50-hp. 850-r.p.m. motor is 292. The average pulley diameter in Fig. 2, shown on the curve, is 14 in., the minimum diameter pulley recommended is 11 in. in diameter and the maximum face is 14 in. For economical operation the belt speed should not exceed 5500 ft. per min. Fig. 2 gives the maximum pulleys for various motor speeds to guard against exceeding the foregoing belt speed. For example, the full-load torque of a 200-hp. 1750-r.p.m. motor is 584. The curve shows that for this torque an 18-in. pulley is usually employed. On account of the belt-speed limitation, a 12-in. pulley only can be used. Since this pulley

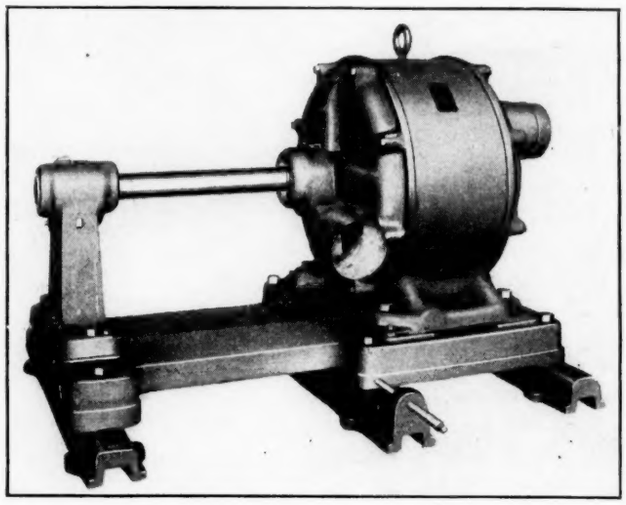


FIG. 3. THREE-BEARING MOTOR FOR BELTED SERVICE

is below the minimum recommended, in this case a motor with an outboard bearing should be used. In general, the larger high-speed motors are used for direct coupling

TABLE III. MOTOR SPEEDS RECOMMENDED TO OBTAIN DESIRED SPEEDS OF DRIVEN MACHINE

Speed of Driven Shaft, R.P.M.	Motor Speed, R.P.M.
600 to 1,500	1,750
350 to 600	1,150
250 to 350	850
150 to 250	690
100 to 200	600
80 to 100	1,150 back geared
50 to 75	850 back geared

and the question of belting does not come up. If it does, it must be handled as explained. In general, for motors up to 250 hp., 580 r.p.m., a two-bearing motor can be

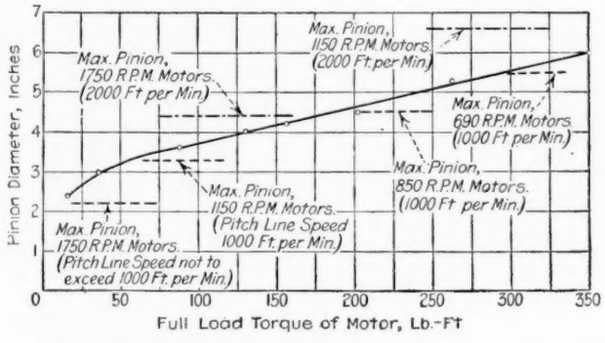

Max. Pinion, 1750 R.P.M. Motors. (2000 Ft. per Min.)
Max. Pinion, 1150 R.P.M. Motors. (2000 Ft. per Min.)
Max. Pinion, 690 R.P.M. Motors. (1000 Ft. per Min.)
Max. Pinion, 850 R.P.M. Motors. (1000 Ft. per Min.)
Max. Pinion, 1150 R.P.M. Motors. (Pitch Line Speed 1000 Ft. per Min.)
Max. Pinion, 1750 R.P.M. Motors. (Pitch Line Speed not to exceed 1000 Ft. per Min.)
Pinion Diameter, Inches
Full Load Torque of Motor, Lb.-Ft
0 1 2 3 4 5 6 7
0 50 100 150 200 250 300 350

FIG. 4. RELATIONS OF FULL-LOAD TORQUE OF MOTOR AND PINION DIMENSIONS

used. Above this capacity, however, a three-bearing motor should be used (see Fig. 3).

For geared drive, limitations similar to those given for belt drive are shown in Fig. 4. The curve indicates the relation of minimum pinion to rated full-load torque of motor. For instance, a 15-hp. 850-r.p.m. motor, full-load torque, Table I, is 87.5. The minimum pinion that

can be used successfully is 3.6 in. in diameter. This curve also gives limitations in the diameter of pinion so as not to exceed 1000 and 2000 ft. per min. For variable speed motors gear speeds of 1000 ft. per min. can be exceeded; however, 1000 ft. per min. should not be exceeded where quiet operation with steel gears is desired. Where rawhide, cloth, micarta or other special composition pinions are employed, a speed of 2000 ft. can be used. Up to 75-hp. 850-r.p.m. motors can be geared without the use of an outboard bearing. In larger sizes, however, an outboard bearing is recommended.

The limitations given for geared drive also apply when chain drive is used, the minimum diameter of the sprocket being the same as the minimum diameter of the pinion. For coupled drives, either a flexible or a rigid coupling is used to connect the motor to the driven machine.

For geared, chain or coupled drive, a motor without a sliding base should be specified; and in setting the motor in place a dowel is recommended to insure exact alignment in case the motor is taken off the base and later put back in place.

In specifying the dimensions of motors the dimension which is of greatest importance in making application is the distance from the base to the center line of the shaft. Manufacturing conditions are such that it is impossible to make this dimension exactly as specified. Hence, the following tolerance limits are specified:

On all machines up to and including those having a height of center of shaft above the base of 24 in. and less, limits of plus 0 and minus $\frac{1}{32}$ in. variation from the nominal dimension may occur. On all machines on which this distance is greater than 24 in. the variation shall not exceed plus 0 and minus $\frac{1}{16}$ in. Liners must be used to obtain the exact specified dimensions.

Brady Traveling-Grate Stoker

The illustrations show a traveling-grate stoker designed particularly for low-grade coals, especially of the high-volatile noncaking kinds. A distinctive feature is the use of grate bars that do not form part of the driving mech-

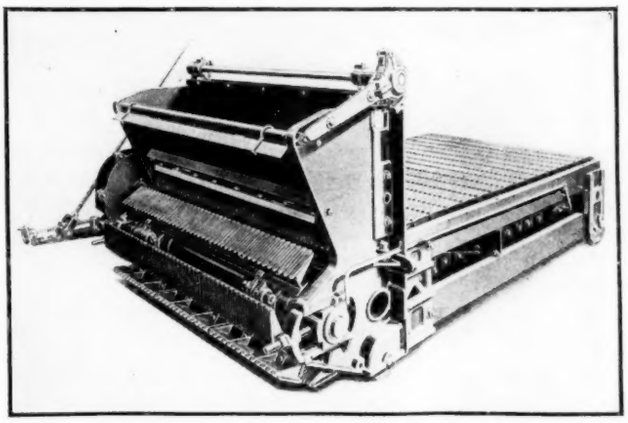


FIG. 1. BRADY SIMPLEX TRAVELING-GRATE STOKER

anism of the stoker. Separate driving links of semi-steel traveling on rollers supported by the side frames are used. To each pair of opposing links a steel tee-bar is secured, and to this tee-bar sections of cast-iron grate bar having a total length equal to the width of the furnace are bolted. Near the front and rear edges two steel rods are cast in the grate-bar sections throughout their full length.

The side frames are some distance from the fire and are made up of structural-steel beams instead of cast iron. The chain tensions are conveniently located at the front, as indicated in Fig. 1. The geared reduction drive is mounted upon the front-axle bearing, so as to be self-

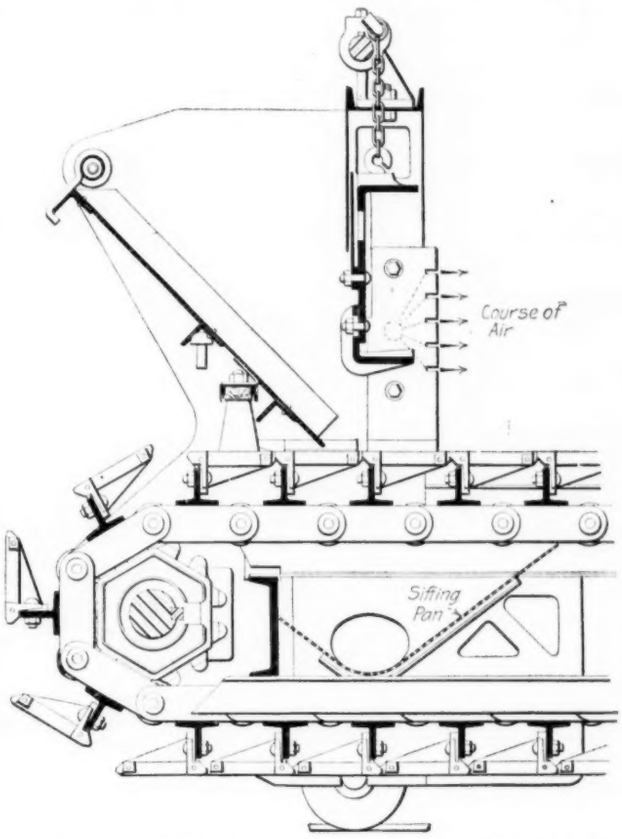


FIG. 2. SECTIONAL VIEW THROUGH FRONT PART OF STOKER

adjusting when the grate tension is changed. Sifting pans between the upper and lower runs of grate catch the fine coal that may drop through from the fuel bed. In the larger-sized stokers a screw conveyor is provided to remove the fine coal from the sifting pans.

As shown in Fig. 2, the sheet-metal front of the coal hopper is held in place by hooks at the top. This front is supported on trunnions which permit it to be brought to a horizontal position, allowing coal to be easily removed from the hopper and giving access to the furnace should it be desirable to dump the fire quickly or break up a banked fire.

Moreover, the cast-iron gate has an isolated outer cover of sheet metal in two sections and on the inner side is protected by standard 9-in. firebrick held in place by removable shoes. Between the cover and the gate a free circulation of air is maintained. This air becomes preheated and is discharged into the furnace to mix with the volatile gases from the coal. As the coal tends to burn more rapidly along the sides than throughout the central portion of the grate area, owing to close proximity of the hot side walls and other influences, the gate is arranged to give a heavier feed at the sides. When the fuel reaches the rear of the furnace, the fire line is even. To control the depth of the fuel bed, the gate may be raised or lowered by a ratchet lever.

The stoker is built by the James A. Brady Foundry Co., Chicago.

Heat Balance of an Absorption Plant

By Julian C. Smallwood*

SYNOPSIS—Considers the factors involved in the making of a heat balance of an absorption refrigeration plant.

The over-all heat transfers in an absorption refrigeration plant may be summarized very briefly as follows: Energy is added to the system, first by the steam supplied to the generator, second by the work of the ammonia pump, and third by the heat added to the brine during the refrigerating process. Heat is removed from the system by circulating water, first in the ammonia condenser, second in the absorber, and lastly, in the weak-aqua cooler and the rectifier. The energy added equals the heat removed, as itemized, plus or minus radiation.

A study of this over-all heat balance is useful, but before making comparisons of grand totals, it is preferable to analyze the performance of separate units. Of these it is the purpose here to deal with the generator and the absorber.

To review the action of the generator, strong aqua ammonia enters at a comparatively low temperature, to which heat is added by steam pipes. Some of the ammonia is thereby boiled out of the water holding it in solution. There result from the process a quantity of superheated anhydrous ammonia, mixed with a small percentage of steam, and a larger quantity of weak aqua, comparatively hot, which is to be returned to the

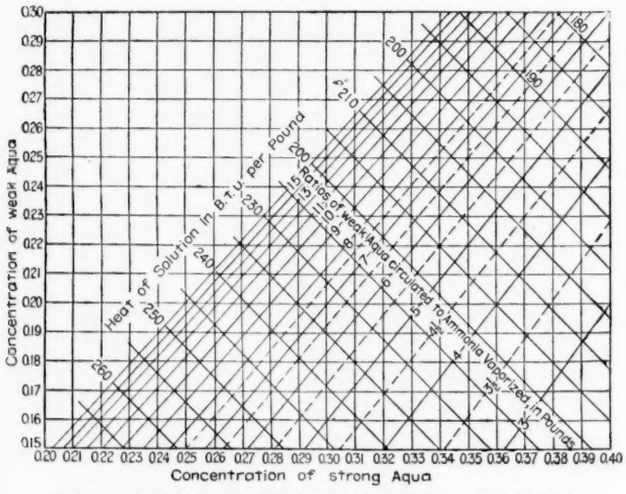

Concentration of Weak Aqua
Concentration of Strong Aqua
Heat of Solution in B.t.u. per Pound
Ratios of Weak Aqua Circulated to Ammonia Vaporized, in Pounds

FIG. 1. HEAT OF SOLUTION OF AQUA AMMONIA

absorber. The heat in the steam supplied goes to vaporize and superheat ammonia from the form of strong aqua and to raise the temperature of the entering aqua to a higher value upon leaving. Furthermore, a certain quantity of heat is required to break the bond between the liquid ammonia and the water holding it in solution, before vaporization can take place. This quantity is additional to that required to vaporize liquid anhydrous ammonia and is referred to as the "heat of solution." Experimental values of it have been made showing that it is independent of pressure and temperature and varies only with the concentration of the solution, being about 347 B.t.u. per pound for very weak solutions (approximately to zero percentage of ammonia) and diminishing as the concentration is increased to a zero value when the concentration is 60 per cent.

It is convenient to base the heat calculations of the ammonia upon a single pound of the NH_3 going through a complete cycle of temperature and state changes. From these results hourly quantities may be figured by multiplying by the number of pounds of anhydrous circulated per hour. Thus, let A represent the latter quantity and W the number of pounds of weak aqua circulated per pound of anhydrous vaporized; then the heat transferred in the generator per hour $= A \times (W \times$ heat added to 1 lb. of the aqua + heat of solution in B.t.u. per lb. of NH_3 + difference in "heat content" of NH_3 per lb., from tables). The quantity in the parenthesis is the heat transferred for the circulation of one pound of the anhydrous.

The product, representing B.t.u. per hour, must equal the heat given up by the steam supplied to the generator, if the losses due to radiation and steam in the superheated ammonia are ignored.

Measurements Necessary in Heat Balance

The measurements necessary to make for the determination of this heat balance are in part the same as those for an economy trial, for which see the article, "Testing Absorption Plants," published in the Oct. 10, 1916, issue of *Power*. In addition it is necessary to determine temperatures of the ingoing and outgoing aqua near the generator, the temperature of the ammonia vapor before it enters the rectifier and the head pressure—readings which should be taken sufficiently to get fair averages. The vapor data are used to determine the "heat content" from the tables or Mollier diagram for ammonia. For the steam-heat quantities, pressure and quality must be ascertained as well as the temperature of the condensate at the generator trap.

To determine the number of pounds of weak aqua circulated per pound of anhydrous (that is, W), it is necessary to measure the concentrations of the weak and strong aqua (referred to as C_w and C_s, respectively) as described in the article previously mentioned. The desired quantity may then be calculated from the formula,

$$W = \frac{1 - C_s}{C_s - C_w}$$

A simpler procedure may be adopted through the use of the accompanying curves. Referring to Fig. 1, the lines slanting diagonally upward from left to right show values of the number of pounds of weak aqua per pound of anhydrous corresponding to various combinations of concentrations. To use these curves, assume, for example, that the concentration of the strong aqua is 0.34, and of the weak, 0.24. On the chart the lines representing these values intersect between the curves marked 6.5 and 7, at about one-fifth of the distance across, so the value of W is 6.6.

*Professor, department of mechanical engineering, Johns Hopkins University, Baltimore, Md.

This chart also gives the "heat of solution," which is plotted from the experimental values of H. Mollier.[1] As previously remarked, this depends only upon the concentration. During the driving-off process in the generator, the concentration varies from that of the strong aqua to that of the weak. It is the average concentration, then, that determines the heat of solution. This condition is met in the chart, as before, by the intersection of the lines representing the concentrations; the location of this point with relation to the "heat lines" (slanting downward from left to right) gives the heat of solution. For example, using the concentrations 0.34 and 0.24, the point of intersection is about four-fifths of the distance across from the 205 to the 210 B.t.u. line. Therefore the heat of solution is 209 B.t.u.

We now have means of finding the number of pounds of weak aqua per pound of ammonia vaporized and the heat of solution per pound. Referring to the heat equation for the generator, already given, it will be noticed that there are still to be found the heat added to one pound of the weak aqua and the difference in "heat content" of the NH_3 before and after vaporization. The latter is readily found from the ammonia tables or Mollier diagram, being the difference between the total heat of the NH_3 vapor at the head pressure and outgoing temperature and the heat of the liquid NH_3 at the temperature of the incoming strong aqua.

Heat Capacity Ammonia and Water Mixture

Considering, now, the heat added to one pound of the aqua passing through the generator, it is to be remarked that there are no tabulated values of the heat of the liquid of mixtures of ammonia and water, or of the specific heats of such mixtures. It will, however, be sufficiently accurate to assume that the heat capacity of a combination of ammonia and water in definite proportion is the sum of the heat capacities of the constituents, according to their proportion. Thus, if we call the heat of the liquid of ammonia q_a and of the water, q_w (as tabulated in the ammonia and steam tables, respectively), then for a mixture of C pounds of ammonia and $1 - C$ lb. of water, the heat of the liquid (aqua ammonia) $= q_a C + q_w (1 - C)$. Values of this quantity at various temperatures and concentrations are shown graphically in Fig. 2, the highest curve of which gives (vertically) the heat of the liquid of pure ammonia, the lowest curve, of unmixed water, and the intermediate curves, of mixtures of the two denoted by their concentrations. The heat of the liquid of aqua at concentrations intermediate between those shown may be obtained with sufficient accuracy by interpolation.

Coming now to detailed calculations,[2] let us assume the following data:

Concentration, weak aqua, $C_w = 0.24$.
Concentration, strong aqua, $C_s = 0.34$.
Head pressure = 100.3 lb., gage.
Temperature of outgoing NH_3 = 150 deg. F.
Temperature weak aqua = 180 deg. F.
Temperature strong aqua = 130 deg. F.

From Fig. 1 is obtained the value 6.6 as the number of pounds of weak aqua leaving the generator per pound of ammonia vaporized. From Fig. 2 the heat of the liquid of one pound of 24 per cent. aqua is found to be 158 B.t.u. at 180 deg. and 102 B.t.u. at 130 deg. Consequently, the heat added to the aqua per pound of ammonia vaporized is $6.6 \times (158 - 102) = 370$ B.t.u. From Fig. 1, from the given concentrations, heat of solution = 209 B.t.u. From the ammonia tables, the total heat of ammonia at 100.3 lb. gage and 150 deg. is 609 B.t.u., and the heat of liquid ammonia at 130 deg. (its incoming temperature) is 115 B.t.u. (also obtainable from Fig. 2). The heat added to the NH_3 to raise it from the liquid to the superheated condition is consequently 609 — 115 = 494 B.t.u. Adding these three

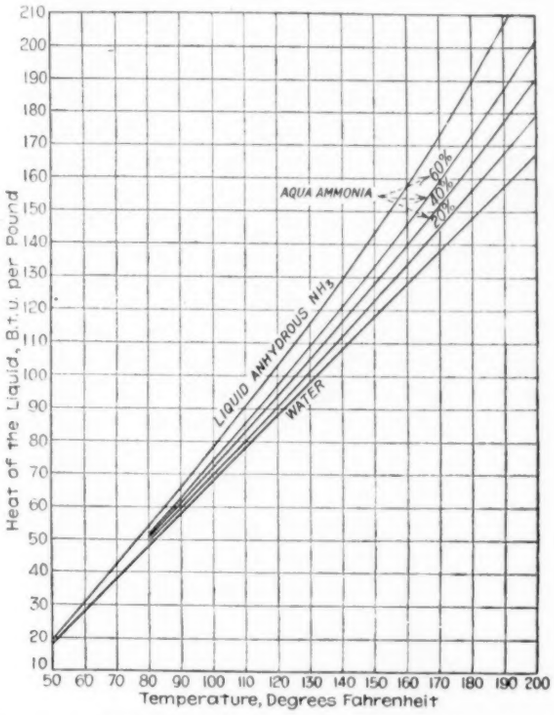


FIG. 2. HEAT OF THE LIQUID FOR WATER, AQUA AMMONIA AND ANHYDROUS AMMONIA

heat quantities ($370 + 209 + 494 = 1073$ B.t.u.), we have the heat added in the generator to effect the complete circulation through the plant of one pound of anhydrous ammonia. As before mentioned, this ignores the loss through vaporization of water with the ammonia, afterward removed by the rectifier, but this loss should be small.

The steam-heat quantities involve the determination of the weight of steam used for a corresponding ammonia vaporization and may be made as for an economy trial. It should be noted that

$$Lb.\ of\ steam\ per\ hr. = \frac{heat\ added\ to\ NH_3\ and\ aqua\ per\ hr.}{heat\ removed\ from\ 1\ lb.\ of\ steam}$$

The heat transfers in the absorber are essentially the same as in the generator, the only difference being that they proceed from the ammonia media into circulating water, instead of from steam into ammonia media, and heat is given up, instead of taken in, by the NH_3 and aqua. The aqua is pumped from the absorber at a temperature lower than that at which it entered, whereas in the generator the reverse was the case. The heat of solution is *released* in the absorber and must be removed by the circulating water, also a reverse process. The anhydrous vapor, coming from the refrigerator at comparatively low pressure, is taken into solution by the weak aqua, consequently giving up (in addition to the

[1] See Marks' "Mechanical Engineer's Handbook," p. 1728.
[2] The ammonia tables of Goodenough are used in these calculations.

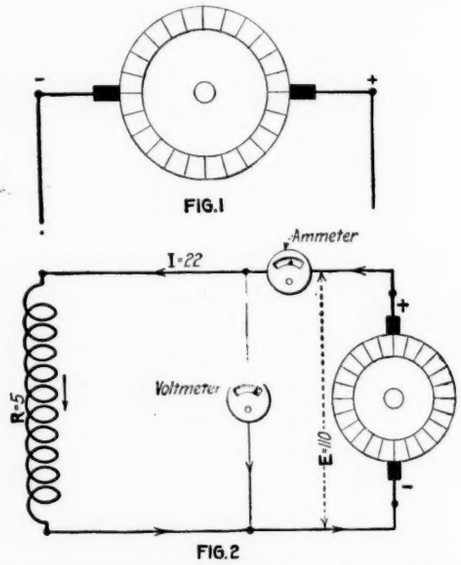
heat of solution) an amount of heat equal to the total heat of the incoming anhydrous minus the heat of the liquid of NH_3 at the temperature of the outgoing (strong) aqua. It will thus be seen that the measurements and calculations for the determination of the heat given up in the absorber per pound of anhydrous ammonia are exactly the same as for the generator.

The heat thus calculated, expressed in B.t.u. per unit of time, equals the heat removed by the circulating water from the absorber in the same time, plus or minus radiation. To obtain the heat removed, it is necessary to measure the circulating water for a definite time, as for an economy trial, and its temperature range between entering and leaving the absorber.

The Electrical Study Course—Ohm's Law

SYNOPSIS—The relation between volts, amperes and ohms is discussed; problems are worked out to illustrate the use of this law; also, problems are given to be worked out by the reader.

In the three lessons on elements of electricity, we became acquainted with three electric units and the common types of electric circuits. The three electric units were the unit of pressure, "volt"; the unit of electric-current flow, "ampere"; and the unit of electrical resistance, "ohm." The volt corresponds to a force in pounds per square inch or a difference of temperature between two bodies or different parts of the same body. It is on just what pressure is that many misleading ideas are cultivated, in that the manifestations of pressure are mistaken for the pressure itself, and when these manifestations are understood, it is considered that what pressure is, is also understood. Mechanical pressure, the manifestations of which we are all so familiar with, is just as mysterious as electrical pressure (volts). Pressure is defined as that which tends to produce motion. It may produce motion



FIGS. 1 AND 2. SYMBOL FOR DYNAMO OR MOTOR AND ELECTRIC CIRCUIT

and it may not. To cause motion the opposing resistance, or, as it is commonly referred to, the reaction, must be overcome.

A steam boiler under pressure looks just the same as one that is cold, and unless some external manifestation is given such as the opening of the throttle valve and an engine is put in motion, or the opening of a cock from which a jet of steam or water is given out at high velocity, we would not be able to tell that the boiler is under pressure. The same thing is true of an electric circuit. A dead circuit looks the same as a live one. The only way that one can be told from the other is by some external manifestation. For example, if an electric lamp is connected to a circuit and it lights, we know that an electric pressure must exist between the terminals to cause a current to flow and light the lamp. Or, again, if the terminals of the circuit are touched with the hand and a shock is received, it is realized that an electric pressure must exist to cause a current to flow and give the sensation that we feel. Therefore, in electricity as in mechanics, pressure is something that is only known to exist by its external manifestation.

The ampere, the unit flow of electricity, is somewhat inexplicit, the same as the gallons in reference to the capacity of a pump. For example, the statement that a given pump discharges 10,000 gal. of water into a tank does not convey much of an idea as to the real capacity of the pump. It may have required a month, a week, a day or an hour for the pump to deliver the 10,000 gal. Each period would represent a different capacity pump. If the statement is made that the pump discharges 10,000 gal. into the tank in 10 min., we then know that the pump has a capacity of at least 1000 gal. per min. Therefore, to get a clear conception of what the pump is capable of doing, it is necessary to know not only the gallons or cubic feet of fluid delivered, but also the time that was required.

The Unit of Electric Current

The case of electricity is analogous. For example, if the terminals of a small battery cell are connected through an ammeter, it may set up a current of 20 or 30 amperes, but this is no indication of the capacity of the cell, for it may be capable of maintaining this rate of flow for a few minutes only. Or, again, a generator on a short-circuit may discharge an instantaneous current into the circuit of many thousand amperes, but this is no indication of what the generator is capable of doing. What we are most interested in, in all commercial machines, is the number of amperes that the machine will deliver continuously. Consequently, in electricity, as in the flow of a fluid, we must consider the time as well as the quantity to get a definite idea of the capacity of a device.

The unit quantity of electricity is called a coulomb, after the French physicist Charles Augustin de Coulomb. The coulomb may be defined as the quantity of electricity that passes any cross-section of a circuit, in one second, when the current is maintained constant at one ampere strength. Hence, a current of electricity flowing through a circuit is measured in so many coulombs per second, just as the rate at which a quantity of fluid delivered by a pump is measured in so many gallons per second, or

per minute. The coulomb is only the quantity of electricity as the gallon or pound is the quantity of matter. In general practice the current strength (amperes) and not the quantity (coulombs) is what we have to deal with; consequently, the coulomb is seldom mentioned.

It was pointed out in an earlier lesson that the three electrical units, volts, amperes and ohms, have been so chosen that one volt pressure impressed upon a circuit of one ohm resistance would cause a current of one ampere to flow. The relation between volts, amperes and ohms may be shown by the expression amperes $= \frac{\text{volts}}{\text{ohms}}$; that is, the current flowing in a circuit is equal to the volts impressed on the circuit divided by the resistance of that circuit. This law was first defined by Dr. Georg Simon Ohm and may be said to be the beginning of the scientific study of electricity.

The three electrical units are represented by symbols; namely, volts by E, current by I and ohms by R. Therefore, in symbols the expression for the current is $I = \frac{E}{R}$. This formula may be transposed so as to read $R = \frac{E}{I}$; that is, the resistance of a circuit is equal to the volts divided by the current. Also, the expression may be derived, $E = RI$, which indicates that the voltage impressed upon a circuit is equal to the product of the resistance of the circuit times the current.

How To Remember Ohm's Law

The importance of Ohm's Law makes it essential that the reader remember the foregoing formulas, or have some means for deriving them when needed. Anyone of the formulas might be memorized and transposed to give the other two, but this requires a knowledge of elementary algebra. Probably the easiest way to express this law and remember it is to write $\frac{E}{RI}$. When the three symbols are arranged in this form, all that is necessary to derive any one of the three formulas is to take the element that you wish to find out of the group and place it with an equality sign to the left of the remaining two. For example, to derive a formula for finding the value of E, take E from the top of the group and place it, with an equality sign between, to the left of the other two elements, thus: $E = RI$. To obtain an expression for the value of I, take I out of the group and place it, with an equality sign between, to the left of the remaining two, thus: $I = \frac{E}{R}$. Likewise for finding the value of R, take R out of the group and place it with an equality sign between in front of the remaining two symbols, thus: $R = \frac{E}{I}$. In each case the only change made in the original arrangement of the symbols $\frac{E}{RI}$ was to take the symbol representing the quantity that was to be determined out of the group and place it in front of the equality sign. This makes it easy to recall any one of the three formulas.

The unit of electric pressure has a great many different names, including volts, electromotive force (e.m.f.), potential, drop of potential, difference of potential, etc., but they all mean one and the same thing.

Ohm's law, $I = \frac{E}{R}$, is a very simple expression, yet when a thorough knowledge is obtained of it in all its applications, the subject of direct current is quite thoroughly understood. Also, the knowledge will greatly assist in understanding alternating current.

Fig. 1 shows what is usually recognized as a symbol to represent a direct-current generator or motor. It might be stated here that an electric generator and dynamo is one and the same thing. Broadly speaking, a generator is anything that produces something. A gas producer is a generator of gas; a steam boiler, a generator of steam; and a dynamo, a generator of electricity. However, the electric industry seems to have usurped the word generator for its own particular use, and now when we speak of a generator, it is intended to mean a dynamo unless otherwise specified.

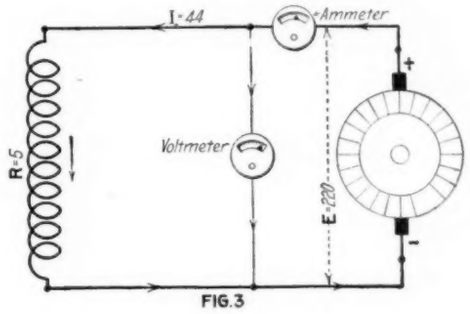


FIG. 3

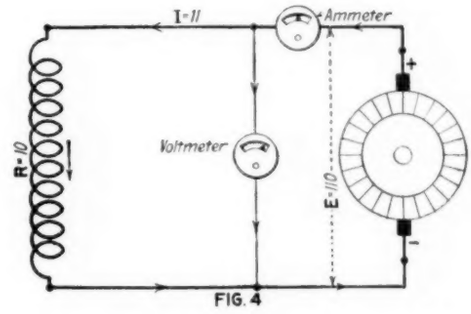


FIG. 4

FIGS. 3 AND 4. SAME AS FIG. 2 EXCEPT HAVING DIFFERENT VALUES FOR E, I AND R

In Fig. 2 is represented a direct-current generator connected to an external circuit. $E = 110$ means that there are 110 volts at the generator terminal and would be indicated by the voltmeter shown connected between the positive and negative side of the circuit. $R = 5$ indicates that the resistance of the circuit is 5 ohms, and $I = 22$ reads that there are 22 amperes flowing in the circuit, which should be the reading of the ammeter connected in series in the line. The values on Fig. 2 have been chosen according to Ohm's law and necessarily would have to be for them to have any meaning. By applying the formulas already given, the relation between the values will be seen. For example, suppose we know the volt E and the resistance R and wish to find the current in amperes. Then, by using the expression, amperes $= \frac{\text{volts}}{\text{ohms}}$, or $I = \frac{E}{R}$, we have $I = \frac{110}{5} = 22$ amperes, as indicated in the figure. On the other hand, if the resistance R and the current I are known, we may find the volts by the formula, volts = ohms $\times$ amperes, or $E = RI = 5 \times 22 = 110$ volts. Again, with the volts E

and the current I given, to find the resistance R, we may write ohms $= \frac{\text{volts}}{\text{amperes}}$ or $R = \frac{E}{I} = \frac{110}{22} = 5$ ohms.

If 100 gal. of water per minute was flowing through a given size pipe at 50 lb. per sq.in., by increasing the pressure to 100 lb. per sq.in., we would expect to increase the amount. This is also true in an electric circuit, as indicated in Fig. 3. Here the conditions are the same as in Fig. 2, except that the volts E have been increased from 110 to 220. Then the current $I = \frac{E}{R} = \frac{220}{5}$ = 44 amperes, as indicated. This is true in all cases. If the pressure is doubled on a given circuit, the current will be double.

At 50 lb. per sq.in., if 100 gal. of water per minute are flowing through a pipe, of 0.5 sq.in. cross-section, then through a pipe of one-half this cross-section, 0.25 sq.in., we would expect to get only one-half as much, or 50 gal. per min. This is also true in an electric circuit, as seen from a consideration of Fig. 4, which is the same as Fig. 2 except that the resistance of the circuit has been doubled; that is, increased from 5 to 10 ohms. The increase of resistance may have been accomplished by using a wire of the same material and length as in Fig. 2, but of one-half the cross-section; or the size of the wire may have remained the same as in Fig. 2, but the length doubled; or, in fact, all kinds of combinations can be made to obtain this result. In this problem the current $I = \frac{E}{R} = \frac{110}{10} = 11$ amperes as shown. This, then, holds true with our water analogy.

What we have seen in the example is just what would be expected; namely, that if the resistance is doubled and the pressure maintained constant, the current will be halved, or if the current is to be decreased by 2, through a given circuit, the voltage also must be decreased by 2.

In the foregoing example it has been seen that it is necessary to know two of the elements to find the third; that is, if the resistance of a circuit is to be calculated, it is necessary that the voltage and current be known, or if the amperes flowing in a circuit are to be determined, it will be necessary to know the volts and the resistance of the circuit.

Hereafter many of the lessons will involve electrical calculations, and at the end of each lesson will be given problems representative of those considered in the lessons. In this way you will have an opportunity of applying the principles laid down in the discussion. In the following lesson the problems will be worked out, so that the method of working out the problems and their answers can be checked.

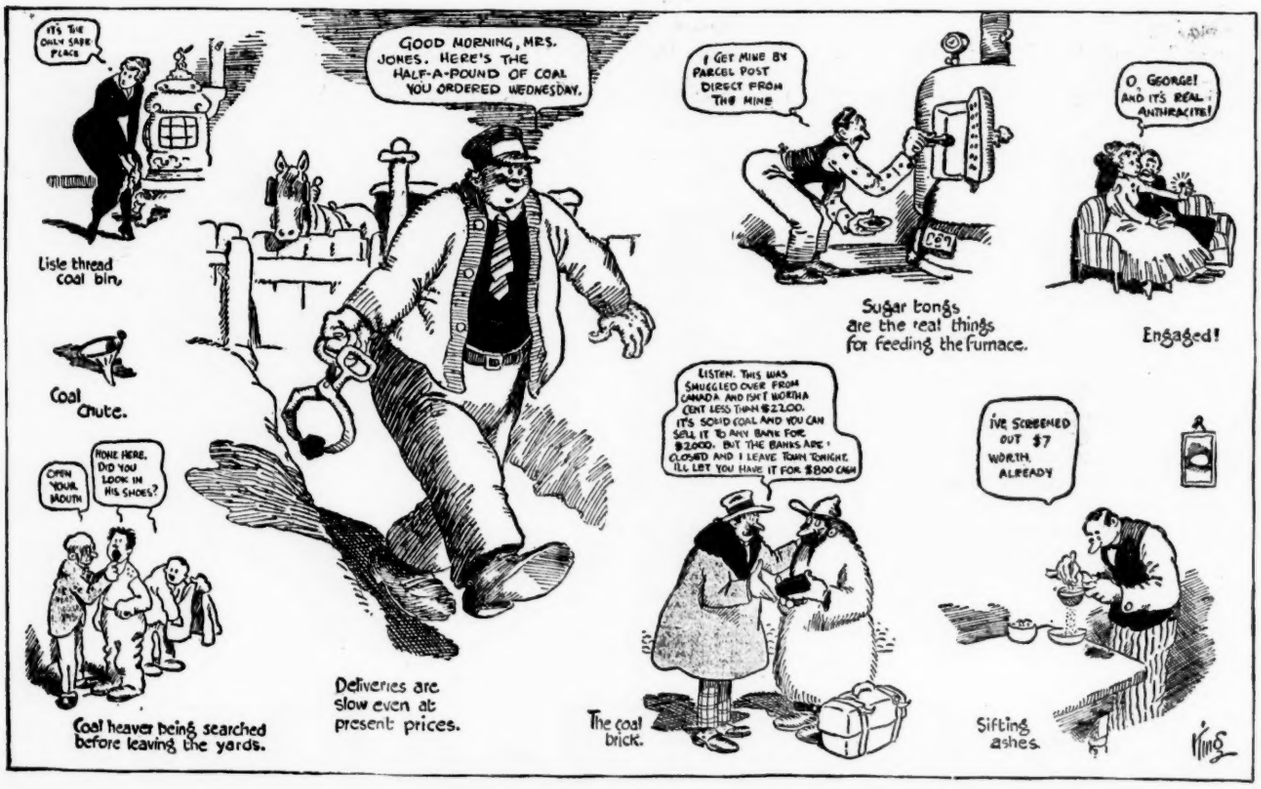
Problems to be worked out:

1. Find the value of the electric pressure that must be impressed upon the terminals of a coil of 12.5 ohms resistance to cause a current of 15 amperes to flow through it.

2. A current of 6.6 amperes flows through an arc lamp connected to a 110-volt circuit; what is the resistance of the lamp?

3. Determine what the ammeter reading should be when connected in a circuit of 35 ohms, when the voltmeter indicates 157.5 volts.

4. A voltaic cell has an internal resistance of 0.25 ohm and a pressure of 1.75 volts between its terminals; if the two terminals of the cell are connected together by a wire of negligible resistance, what is the value of the current that will flow?


IT'S THE ONLY SAFE PLACE
GOOD MORNING, MRS. JONES. HERE'S THE HALF-A-POUND OF COAL YOU ORDERED WEDNESDAY.
I GET MINE BY PARCEL POST DIRECT FROM THE MINE
O, GEORGE! AND IT'S REAL ANTHRACITE!
Lisle thread coal bin.
Sugar tongs are the real things for feeding the furnace.
Engaged!
Coal Chute.
LISTEN. THIS WAS SMUGGLED OVER FROM CANADA AND ISN'T WORTH A CENT LESS THAN $2200. IT'S SOLID COAL AND YOU CAN SELL IT TO ANY BANK FOR $2000. BUT THE BANKS ARE CLOSED AND I LEAVE TOWN TONIGHT. I'LL LET YOU HAVE IT FOR $800 CASH
I'VE SCREENED OUT $7 WORTH ALREADY
OPEN YOUR MOUTH
NONE HERE. DID YOU LOOK IN HIS SHOES?
Coal heaver being searched before leaving the yards.
Deliveries are slow even at present prices.
The coal brick.
Sifting ashes.
King

WHEN THE PRICE OF COAL IS UP

Ringelmann Smoke Densities

By S. H. Viall

Smoke inspectors frequently receive complaints from citizens regarding smoke. The citizen making the complaint usually has difficulty in describing the density of the smoke emitted, and by the use of ambiguous terms —clear enough to himself, perhaps—may convey an entirely different conception to the inspector. The Ringelmann chart is a definite measure of smoke densities, and with a little experience the observer will have no difficulty in making an accurate report. The chart should be more generally used so that eventually the various densities of smoke will be thought of in numbers of the Ringelmann scale.

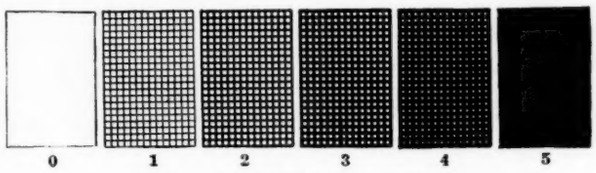


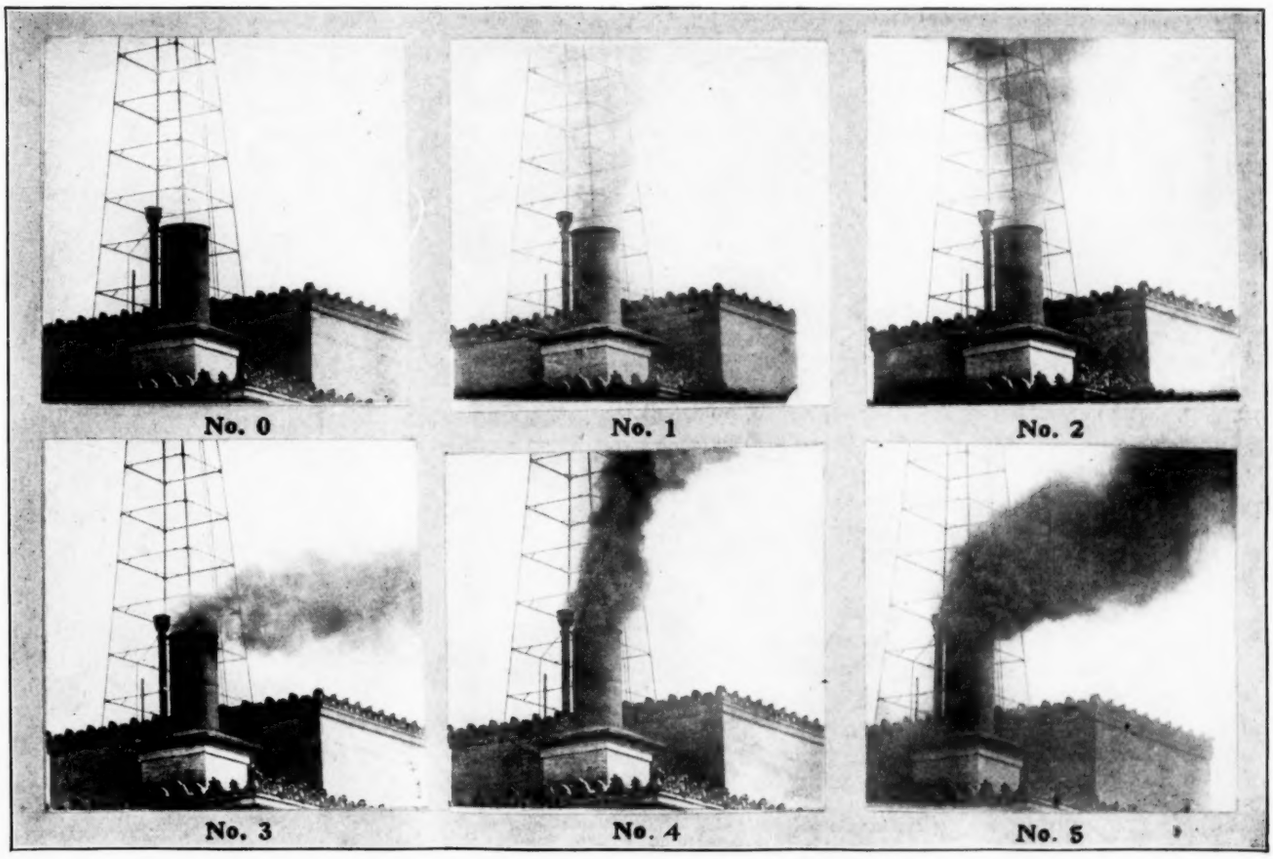
FIG. 1. RINGELMANN CHART

As shown in the miniature chart, Fig. 1, the Ringelmann scale is made up of six rectangles, four of which contain horizontal and vertical lines so spaced and of the proper weight to give in the case of No. 1 an area 20 per cent. black; No. 2, 40 per cent. black; No. 3, 60 per cent. black; and No. 4, 80 per cent. black. No. 0 is clear and No. 5 all black. The chart is to be placed between the observer and the stack at a sufficient distance from the observer's eye so that it loses the checkerboard appearance and looks like an even shade. To help identify the various shades the accompanying photographs are reproduced (Fig. 2).

All observations of smoke densities should be taken directly at the top of the stack. In the case of No. 0 photograph the stack appeared to the eye to be perfectly clear. The camera shows a slight haze, but this is due to the refracted light passing through the hot gases. It will be noticed that No. 3 is dense at the top of the stack, although structural steelwork a short distance away can be seen through the smoke. In spreading out, smoke of No. 3 density is quickly diluted. Many of the smoke ordinances of American cities specify that smoke corresponding to No. 3 of the Ringelmann scale shall be considered dense smoke, and it is declared to be a nuisance with certain exceptions such as when new fires are being built or old fires are being cleaned.

There is a marked difference in the amount of light that will pass across the stack to the observer's eye in the various densities with the exception of Nos. 4 and 5. In these two shades the greatest difference to the eye or camera is one of volume, close observation being required to notice the difference in color.

Some of the modern furnaces for high-capacity work emit a gray-colored haze from the top of the stack. These gases at times are similar in color to exhaust steam and do not correspond to the shades of the Ringelmann scale. They are described in Ringelmann numbers corresponding to the percentage of light the gases prevent from passing across the top of the stack to the observer's eye. In average practice, however, it is necessary only to follow the color and density as shown in the photographs.



FIGS. NO. 0 TO NO. 5. SMOKE DENSITIES. EACH ILLUSTRATION SHOWS SMOKE OF A DENSITY CORRESPONDING TO A SHADE OF A RINGELMANN CHART

Visits of Inspector Brown—XXVI

By J. E. Terman

SYNOPSIS—The Chief explains the principles of diagraming the formula for the stay-bolt in the code. He shows how a formula resulting in a curved diagram can be represented by a straight line.

"Say, Brown, come into my office if you have time, and we will take up that problem of making a diagram for the stay-bolt formula in the Code."

"Sure," said Brown, as he followed the Chief.

"While I say that we will take up the question of diagraming the formula, we will probably not actually get to that this afternoon," said the Chief. "We will, however, get at the principles involved so that the diagraming of that particular formula will be comparatively easy when we do come to it. You will remember how it was demonstrated that a line representing the formula $y = ax$ or $y = ax \pm b$ was a straight line. Well, suppose the formula to be diagramed had been $y^2 = ax$.....(1), the line representing this formula would be like this," (see Fig. 1) "where a has a value of 2 and the values of x and y are as shown. We do not intend to consider any diagrams that are not made up of straight lines, so unless we can do something to change this into a straight-line formula, the equation $y^2 = ax$ will have to be passed up."

"Well, Chief, I don't see how you are going to do it," said Brown.

"The explanation is simple if you will keep firmly fixed in your mind that $y = ax$ or $y = ax \pm b$ is a straight line. The reason that the formula $y^2 = ax$ is not represented by a straight line in this case" Fig. 1, "is because the values of y were laid off on the vertical axis rather than the values of y^2. If the values of y^2 are used instead of those of y, the result will be like this," continued the Chief, drawing Fig. 2. "The reason that a straight line

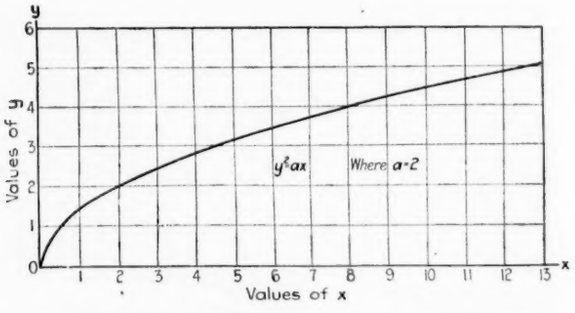


FIG. 1. CURVE FOR y^2 EQUALS ax FORMULA

will represent formula (1) in this case is the same as in the case of the formula $y = ax$.

"From formula (1), you will notice that $\frac{y^2}{x}$ is always equal to the constant a, and since y^2 and x in this case represent the bases and altitudes of a series of right-angled triangles, the hypotenuse of all such triangles will coincide where the bases and the acute angle at the end of the base lines coincide." See XXI, page 783, Dec. 5, 1916. "Of course this fact could have been noted from formula (1) at once; for writing that formula thus, $(y^2) = ax$ (I have used the parenthesis to indicate that y^2 and not y is the variable to be used), it is seen that it is in just the same form as $y = ax$. It is not convenient to deal with the values of y^2 instead of y in most cases that are met in practice, but that is not a serious problem. Instead of using the evenly spaced horizontal lines as I have numbered at the left of this sketch," Fig. 2, "only such of these horizontal lines as may be required for values of y need be used, as indicated on the right of the sketch.

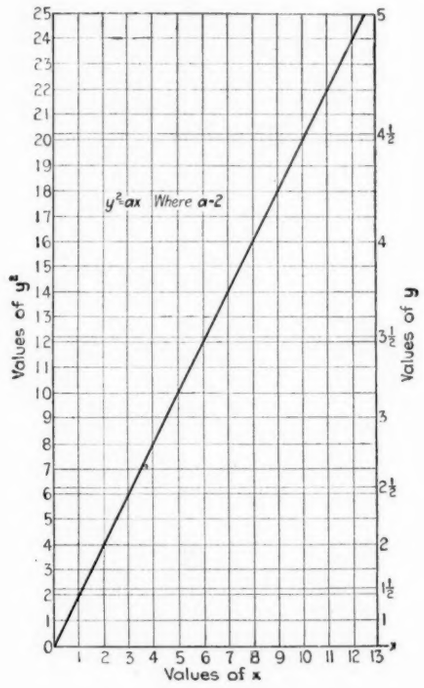


FIG. 2. DIAGRAM WHEN THE VALUES OF y^2 ARE USED INSTEAD OF y

You will see that I have indicated where horizontal lines that would represent values of $1\frac{1}{2}$, $2\frac{1}{2}$, $3\frac{1}{2}$ and $4\frac{1}{2}$ for y would be located, as well as those lines for the whole numbers, the values of y^2 in these cases being 2.25, 6.25, 12.25 and 20.25.

"You will see, Brown, that all that is necessary to make a diagram of the formula $y^2 = ax$ with straight lines is to lay off the horizontal lines representing ordinates, at such distances apart that they would represent the values of y^2, and label these lines with the corresponding values of y."

"That is certainly easier than plotting a lot of curves, as would be required in this case," said Brown, indicating Fig. 1.

"You can see," continued the Chief, "that if the formula had been $y^3 = ax$, it could be represented by straight lines in the same way; that is, by laying off the ordinates to represent the cubes of the values of y and labeling such lines as would be necessary for the purpose for which the diagram was made, with the corresponding values of y, the same as in the case of the squares."

"Say, Chief, suppose the formula had been $y^2 = ax^2$, how would you have been able to represent it by a straight line for any particular value for a?" asked Brown.

"You don't really mean that, Brown, for that is already a straight-line formula. You must have forgotten some of your algebra. The formula $y^2 = ax^2$ is the same as $\sqrt{y^2} = \sqrt{ax^2}$, which equals $y = \sqrt{ax}$, and since a is to represent a constant quantity, this formula could be represented by a straight line without any tampering with the ordinates or abcissas. What you probably had in mind was that if the formula had been $y = ax^2$, how could it have been represented by a straight line? In that case, it would of course be necessary to lay off the values of x^2 on the axis of x and label the different lines required, with the corresponding values for x. If the formula should have been $y^2 = ax^3$, then it would be necessary to lay off squares on the axis of y and cubes on the axis of x, and then for each particular value of a the formula would be represented by a straight line passing through the intersection of the x and y axes.

"The methods just described are not the only ones that may be used to represent the values of these different formulas by straight lines. You will usually find that the use of logarithms is resorted to in order to accomplish the desired purpose. I have shown you this method first, Brown, for two reasons: It is more readily understood in the first place, and in the second, it will be found to be the most useful in the average case. If you have a formula such as $y^2 = ax \pm b$ (2) or $y = ax^2 \pm b$ (3) or variables with any other exponents, the values represented by such formulas may be represented by means of straight lines, if the positions of the ordinates or abcissas, or both as the case may be, are arranged to represent the actual value of the whole term instead of the

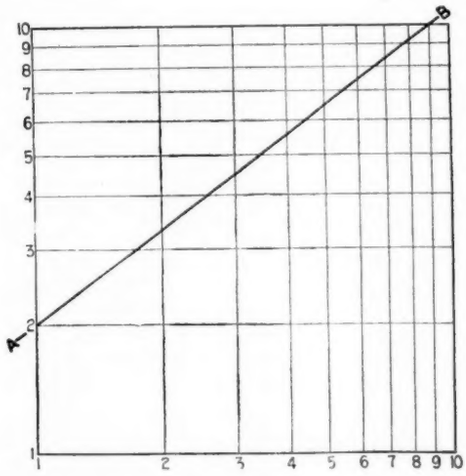


FIG. 3. SCALE OF LOGARITHMIC PAPER WITH VERTICAL AND HORIZONTAL AXES THE SAME

value of the variable alone. Formulas (2) and (3) cannot be represented by straight lines by the use of logarithms, for these reasons. You will remember in the use of logarithms that the log of the product of two numbers is the sum of the logs of the two numbers. Also, that the log of a quotient is the log of the dividend less the log of the divisor. If a formula such as $y = ax^2$ is true, then $log\ y = log\ a + 2log\ x$, and since the log of a will be a constant quantity, this formula is seen to be that of a straight line where the distances representing the values of x and y are laid off to a scale representing the logs of these variables rather than representing the variables themselves. Again, if the formula $y = \frac{a}{x^3}$ is true, then $log\ y = log\ a - 3\ log\ x$ would also be true, and it is seen that this formula could be represented by a straight line as before. However, if the formula to be diagramed should be $y = ax^3 - b$, the formula $log\ y = log\ a + 3\ log\ x - b$ would not be true, nor would $log\ y = log\ a + 3\ log\ x - log\ b$ be true, and this formula could not be represented by straight lines by resorting to the use of logs.

"You will observe, Brown, that the ready-made logarithmic paper that you see advertised appears like this,"

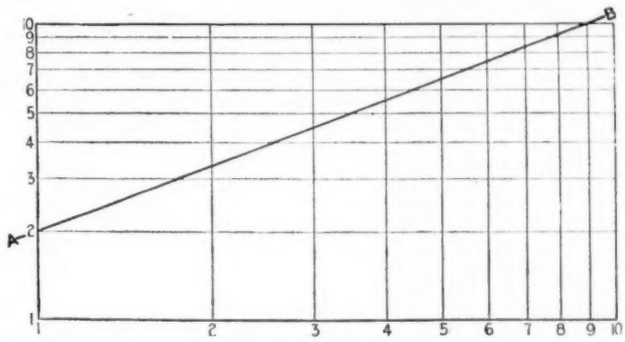


FIG. 4. SCALE OF LOGARITHMIC PAPER, VERTICAL AND HORIZONTAL SCALES BEING DIFFERENT

said the Chief, drawing Fig. 3, "the scale of logs on both the vertical and horizontal axes being the same. The scale on the two axes need not be the same, for such paper made up like this," drawing Fig. 4, "would answer the purpose just as well. In this sketch," Fig. 4, "the vertical scale is one-half the horizontal scale. You can see, that lines such as AB (Figs. 3 and 4) drawn across the paper and connecting similar points, will intersect all lines on both diagrams at points representing the same values."

"Gee, Chief! That is certainly a great labor saver."

"Yes, Brown, it is well to know just what may be done with logarithmic paper, but you will often find it more convenient to use some other method in order to represent a formula by means of straight lines. Where high powers of the variables are used in a formula, it is generally necessary to resort to the use of logarithmic paper, unless the range of values for such variables is small; otherwise the drawing required will be too large for practical purposes, or the divisions will be too close together at some points to be easily read.

"It is about time that we closed this subject for the afternoon, Brown, and it seems that we have not made a start on diagraming that stay-bolt formula in the Code yet, but I guess you are able to see that we are coming to it fast. Come in tomorrow afternoon, and we will see if we can't finish with it."

A Rust Joint May Be Made by mixing 10 parts cast-iron borings or filings to 3 parts chloride of lime and enough water to make a thick paste. Apply to the joint to be made in a thick layer, bolt the patch or flange down tight and let it set for at least 12 hours.

Seattle (Wash.) Municipal Electric Plant, now valued at $5,787,621, has increased its earnings from $45,470 in 1905 to $1,063,730 in 1915 and has a surplus of $213,000 instead of the deficit of $18,000 in 1905. Electricity was being sold at 12c. per kw.-hr. but when the plant was started, council fixed 8½c. for the first 20 kw.-hr., and this has been gradually reduced until now the rate is 5½c for the first 40 kw.-hr. and 2c. for all over that. Probably no city in America is better supplied with street and other public lighting than Seattle.

Steam-Engine Troubles—Valve Setting

By H. Hamkens

SYNOPSIS—This article treats of the testing and the shipping of the engine to the purchaser, valve setting, and lubrication requirements.

With the eccentrics and straps lined up, eccentric rods connected to the straps and rocker arms and the valve-gear parts in position, the setting of the valves can take place. On a wristplate motion, whether driven by single or by double eccentrics, the wristplate or wristplates, as the case may be, must first be placed in the central position, which is indicated by lines on the hub and stand; the valve rods are then adjusted with all the valves on the lap. There are lines for this purpose on the back of the valves and in the counterbore of the port holes, as shown in Fig. 193, marking the cutting edges and the lap of the valves and the edges of the ports. There should also be a line on the steam valves for the lead; but this is often omitted and causes much trouble if left to the discretion of the erecting engineer, whose aim may be to get a nice-looking indicator diagram, showing a vertical admission line, with the result that a pound will develop in the engine from an excess of lead. Next, the wristplate is moved to the extreme positions marked on the stand, and the dashpot rods are adjusted for length so that with the dashpots in their lowest position the catchplates engage with about $\frac{1}{16}$-in. space between. The nuts on the valve and dashpot rods must be set up tight to prevent their shaking loose when the engine is running.

Adjusting Knockoff Levers

The knockoff levers must be connected to the governor and adjusted. For this purpose the governor is blocked in the lowest working position, as shown in Fig. 194, in which the trip levers should just touch the cams when the wristplate is moved to the extreme positions; no cutoff can take place for this position of the governor; if steam is turned on, the engine will take steam full stroke with the dashpots being moved up and down by the steam levers. As soon as the governor lifts $\frac{1}{8}$ in., cutoff must begin. The cams must be adjusted so that cutoff starts practically at the same time at both ends. This part must be tried several times by hand to make sure that the dashpots come down properly. Advancing the governor to the highest position and working the wristplate forward and backward should result in tripping the valve gear before the steam valves open. This will prevent steam from entering the cylinder. A collar on the spindle keeps the governor from rising above this point. It is next lowered to the safety-stop position and the safety cams adjusted to prevent the valve gear from hooking up, the steam arm and the dashpots remaining stationary. To make sure that the wristplate travels correctly, the hook rod is connected and the eccentric moved around the shaft.

Some engine builders do not place the shaft in the bearings in the shop, neither do they adjust the eccentric rods. This is bad practice, dictated by a mistaken idea of saving time. Severe competition is responsible for such methods, and they should not be tolerated. An engine should be finished and erected complete in the factory, with the exception of the flywheel on the larger sizes, and everything should be marked carefully before dismantling. It is unsatisfactory to leave a lot of work to be completed in the field by the erecting engineer. Manufacturers who have not the facilities, especially in the older shops, will sometimes erect one side of a cross-compound engine in one part of the shop and the other side in another. The purchaser should be careful about accepting such work; the best thing for him to do is to employ, as inspector, an experienced engineer, who will make sure that everything is complete before the engine is shipped.

Buyer's Interest in Shipping Engine

The skidding, packing and shipping should also be watched whether the engine is shipped at the risk of the purchaser or not. In case the contract calls for delivery and erection on the purchaser's foundation, it may appear that he is not concerned in that part of the transaction, while as a matter of fact it is much to his interest to have the machinery well protected and carefully handled. For instance, if the cylinder and frame are shipped bolted together, the bolts may be unduly strained in transportation and give trouble at some future time. Finished surfaces should not be exposed to the elements or careless handling; they must be coated with heavy oil and protected against damage by boards.

To locate the eccentric in the correct position on the shaft in relation to the crankpin, place the latter on one of the dead-centers and move the eccentric in the direction of rotation around the shaft until the steam valve that corresponds with the position of the crankpin is on the lead. Now fasten the eccentric and try the other end. If the steam valve at that end also shows the correct lead, the eccentric should be permanently secured, and its position marked on the shaft. On single-eccentric engines, release and compression of the exhaust valves are limited by the lap and lead of the steam valves; therefore, where greater flexibility of the valve motion is desired, double eccentrics must be used. It is safe to state that engines running 100 r.p.m. and over should be provided with double eccentrics to permit setting the valves for an early release and sufficient compression to counteract the inertia of the reciprocating parts.

Function of Compression

Compression weakens the engine, but it serves two purposes: First, to increase the temperature of the steam confined in the cylinder and clearance spaces after the exhaust valve is closed, thus reducing initial condensation and second, to form a cushion for the piston, lessening the shock on the bearing and pins. In the double indicator diagram, Fig. 195, the shaded part illustrates the cushioning effect of early release and compression, without which an engine cannot long run successfully. It is quite evident from the diagram that with a later cutoff the cushion is reduced, which accounts for the pound often noticed when a heavy load is suddenly thrown on. With sufficient cushion, an engine does not have to be keyed tight, thus allowing a thicker film of oil to form between the bearing surfaces, which reduces wear.

Before the back bonnets are screwed on, the valves must be checked for end play, which depends partly on the thickness of the gaskets. As a rule, the length of the valves should be equal to the distance between the inner faces of the bonnets and the back bonnets without gaskets. Making the latter of material $\frac{1}{32}$ in. thick will make the clearance $\frac{1}{16}$ in., which is ample. Steam valves expand more than exhaust valves on account of the higher temperature to which they are exposed—a point which must be watched on a new engine. Exhaust valves are more likely to pound if too short, especially on condensing engines. The valves should be well covered with cylinder oil when put in place; graphite dusted over them and the seats is beneficial.

The governor should be examined carefully; all its parts must be free to move without undue friction. A fly-ball or weighted governor running up to 200 r.p.m. can be tested by fastening a handle to the gear shaft and turning it by hand; its action will show whether it will regulate at the predetermined speed. While this is not an accurate test, it will show defects and give a fair idea of the promptness with which the governor will respond to a change of speed. All governor rods must be free on the pins, with at least $\frac{1}{32}$-in. side play. The governor belt must be endless; that is, the joint must be glued. This is usually done in the evening to give it a chance to dry overnight. Belt lacing or metal belt fasteners should not be used.

The best material for oil guards is planished steel; it can easily be kept clean and will not show oil or grease like painted plates. Galvanized iron should not be used; the zinc coating is liable to come off in places and spoil the appearance. An engine should be provided with ample oil guards over the crank and eccentrics. Large openings in the front of the crank oil guard should be covered with brass-wire gauze of No. 22 mesh to prevent oil from being thrown on the floor. The gauze should be fastened to a frame or door that can be easily removed or opened. Handholes must be provided for feeling the connecting-rod and eccentric straps.

A gravity oiling system with filter and storage tank is desirable, for it will save its cost in a short time and give much better results than drop feeding by means of oil cups. It is more advantageous to pour oil in streams over the bearings and pins (thus reducing their tendency to run hot) and to use the oil over and over again than to feed it in small quantities, most of which goes to waste. Before oil fittings or oil cups are put on, the oil holes must be cleaned and the engineer should make sure that oil poured into them will reach the part for which it is intended and not run along the sides of caps and bearings without touching the vital spots.

The most approved method of cylinder lubrication is by means of a force-feed oil pump, which may be driven from the wristplate or other convenient part of the valve gear. On small engines one feed into the steam pipe, two or three feet above the throttle valve, is sufficient provided the oil is well diffused by the steam, but on engines with cylinders 18 in. diameter and over there should be at least three feeds—one into the throttle valve and one into each end of the steam chest near the valves, where the inrushing steam has a chance to spray oil over the length of the port. The hardest places for oil to reach are the ends of the steam valves, especially on low-

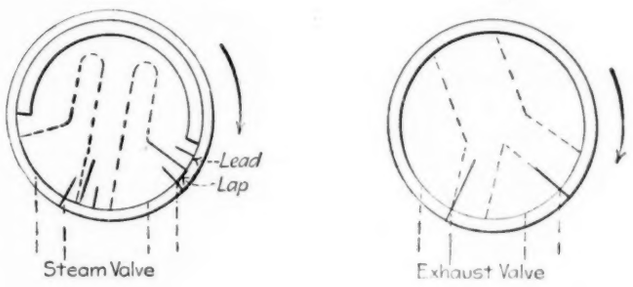


FIG. 193 Markings of Valves and Ports

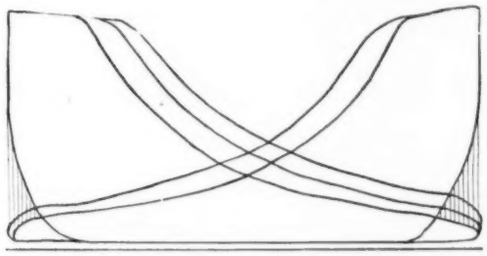


FIG. 195 Diagram showing Cushioning Effect of Compression and Release

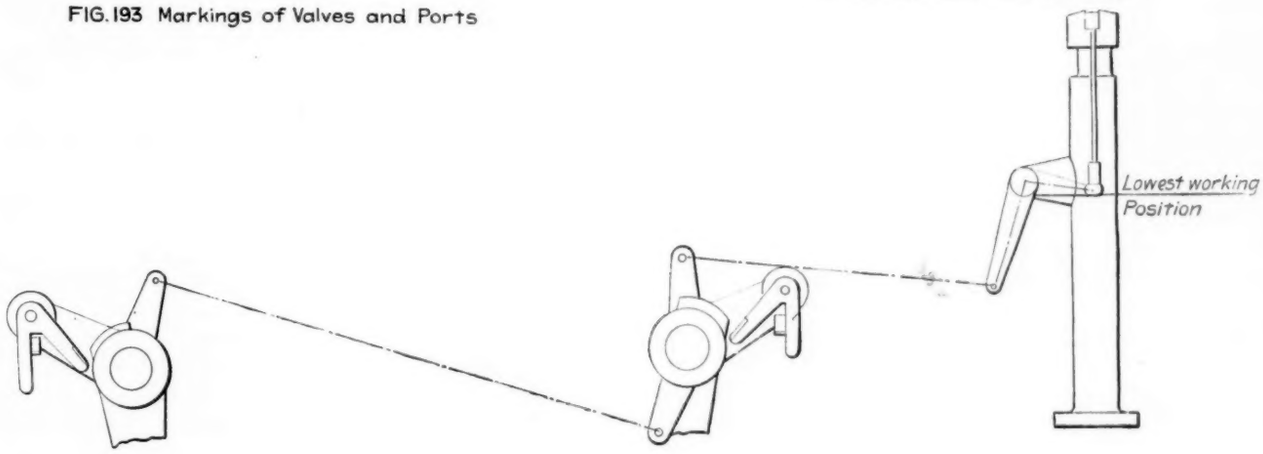


FIG. 194 Triplevers touching the Cams with Governor in lowest working Position

FIGS. 193 TO 195. SHOWING VALVE MARKS, INDICATOR DIAGRAMS AND VALVE-GEAR PARTS

pressure cylinders. Hand oil pumps should be provided here for periodical application of oil. Parts of the valve gear that only occasionally require a few drops of oil may be oiled by hand, while others, like the valve rod and rocker-arm pins, may be lubricated by means of grease cups.

After all the lubricating devices have been put on and tested, the engine is ready to be warmed up. The steam pipe must first be thoroughly drained; next, steam is let into the steam chest either through a bypass or by opening the throttle about half a turn. Throttle valves over 5 in. should be provided with bypasses. If water gets into the cylinder it should be drained off through the exhaust by working the valve gear forward and backward by hand. When thoroughly warmed the valves and piston may be tested for tightness. By letting steam into one end of the cylinder and opening the indicator cock at the other, a leak in the piston can be detected; and by closing both steam valves and opening the indicator cocks, a leak in these valves can be noticed. If the exhaust valves leak, it will show by steam blowing out of the exhaust pipe when the valves are closed. A little steam will frequently blow through on a new engine; not much attention need be paid to this unless the leak becomes serious. The governor should now be raised to the starting position and the engine turned over slowly; everything must be watched closely and plenty of oil pumped into the cylinder and poured on bearings, pins and other moving parts.

Adjustments After Short Runs

After running awhile the engine should be shut down and all the nuts and bolts about the cylinder examined and tightened. If no other adjustments are found necessary, another start may be made, giving the engine a little more steam and increasing the speed until the dashpots begin to drop and the engine is under the control of the governor. This may be continued for about half a day, which will give everything a chance to get into working condition. A mixture of graphite and cylinder oil pumped at intervals into the steam chest will benefit valves and piston, as stated before.

If everything runs satisfactorily, the engine is ready for a trial run with load, which should be increased gradually. With a light load a new engine should be run either with low boiler pressure or with the throttle partly closed until the valve gear and the dashpots are working freely. The engine may be indicated with a view of adjusting the valves. Of course economical performance must not be expected the first few days after starting.

Best Paint for the Engine

To get a lasting coat of paint on an engine, the ordinary shop "paint" should be removed, all cavities and holes cleaned and filled and the castings rubbed smooth with sandpaper or pumice stone. An ordinary house painter or decorator, as a rule, has not the ability to do this work; if the paint is to stay on the engine it must be put on by a coach painter. It must not be affected by extreme changes of temperature or by oil and grease. These are severe conditions, which can only be met by excellent work and materials. The varnish especially, of which the engine should receive two coats, should be of the best quality. The color is, perhaps, a matter of taste; dark colors are preferable on account of showing the oil less than lighter shades. Bottle green seems to undergo less of a change when exposed to heat than red or maroon. If any striping is desired, it should be done with gold leaf. Here again, expert work will show; to daub an engine with green, red or yellow stripes is bad taste. On some engines we see even landscapes or other pictures, making them look like circus wagons.

[*Locating troubles with the indicator is the chief subject of the next article.*]

Turbines in Isolated Plants

By A. G. Christie

One who visits the power plants of hotels, office buildings and loft buildings cannot fail to be impressed by the great predominance of reciprocating engines over steam turbines in such plants. In fact, steam turbines have been little used so far for this work.

It is claimed for the reciprocating engines that their generators make less noise than the turbo-generators, which are sometimes objectionable to tenants. The engine has a low steam consumption during the summer season, when no exhaust steam is required for heating. The small engine-driven high-speed sets have heretofore been cheaper than turbine sets and therefore favored on this basis, and operating engineers who have had no experience with turbines are prejudiced against them. One recently expressed the opinion that "turbines are no good, they run too fast."

Recent types of turbines, especially the new high-speed geared types, seem eminently suited to this class of work, as they make no more objectionable noise than a high-speed engine and generator set. No vibration is produced by unbalanced weight, and there is no clatter of valves in the heating lines from the pulsating exhaust, as in the case of an engine. The exhaust steam is free from oil and is thus suitable for heating or cooking, and the returns can be used in the boiler without filtering. The steam consumption of these turbines has been reduced until it is as good as that of the engines when measured at the switchboard. The price of such units has also fallen until it is practically the same as for the reciprocating engine set. Besides, in most plants of this nature there is always a demand for a certain amount of exhaust steam at all times, and during the winter season the demand for heating purposes usually exceeds the exhaust steam available, and at this time the electric load is greatest. Under such circumstances the value of economy in the engine may be overrated in either case. Probably the greatest factor in favor of the steam turbine is the small amount of valuable building space that is required. This is generally one-half that needed by a reciprocating engine and generator, or even less. There is also a large saving in operating costs, both in oil and waste, and in the labor of attendance, which usually is quite small.

Steam turbines are being used to an increasing extent in such plants in Western cities, but so far have not been very generally adopted in the East. Certainly the present state of steam-turbine development warrants their consideration in any new plants, in spite of the prejudice of some operating engineers.

Increased Use of Coal—In an editorial on "The Increasing Cost of Coal" in the Mar. 13 issue, the statement appeared that under normal conditions the demand for coal doubles about every four years. This should have been about every 14 years.

Editorials

When Doctors Disagree

It is not in the steam stored in a boiler under pressure that the greater part of the accumulated energy resides. True, the energy per pound of steam greatly exceeds the energy per pound of water, but there are a lot more pounds of water than of steam.

Some time ago the question, What is the amount of energy so stored in a pound of heated water? arose in *Power's* editorial staff. Suppose a boiler containing so many pounds of water and so many pounds of steam at one hundred pounds gage pressure were to explode, how many foot-pounds of energy would be let loose upon the neighborhood? What is the potency for damage of such a weight of heated water and steam? To how many pounds of gunpowder or dynamite is it equivalent?

The more this question was discussed the more unsettled did it appear, and to settle it the following request was sent to twenty-odd teachers of, and authors of works upon, thermodynamics, and eminent steam engineers.

> Will you oblige "Power" with an answer to the following question:
>
> What is the heat equivalent, per pound, of the energy released when the pressure upon water at 338.1 degrees (115 pounds absolute) is suddenly reduced to that of the atmosphere?
>
> In other words, what would be the destructive, or disturbing, effect exerted upon the envelopment by each pound of contained *water* when a boiler under 115 pounds absolute exploded?
>
> Do you agree that the energy so exerted per pound of contained *steam* would be expressed by the difference between the internal energies at 115 pounds and at 212 degrees?

Up to this writing the returns stand as follows:

B.T.U.		B.T.U.	
19.6	19.6	10.9	10.9
19.9	19.8	10.6	10.8
19.5	19.7	10.6	10.1
19.7	19.5	10.9	9.9
19.8	19.7	10.9	9.6

Here are two distinct sets of results the value in one set being nearly twice that in the other. The difference comes from the inclusion or noninclusion of the work which is done upon the environment by the steam simply in making room for itself. When the pressure upon the pound of water heated to 338 degrees is reduced to that of the atmosphere, under which pressure the boiling point is only 212 degrees, a portion of the water flashes into steam. This requires the atmosphere to be pushed back to make room for the increased volume, in which process an amount of work is done equal to the product of the atmospheric pressure and the difference in volume of the water at 338 and the mixture of steam and water at 212 degrees.

One school maintains that this work, being expended upon the environment, is properly to be credited to the explosive energy inherent in the heated water. The other school maintains that the energy so exerted has all been absorbed in pushing back the atmosphere, that every heat unit so expended is present in the potential energy of such displacement, and that any damage inflicted or any further result produced must be at the expense of other heat units; that therefore the work done by the steam upon the atmosphere in making room for itself should not be included in the explosive effect.

An analysis of the question is given in the leading article of this issue and *Power* would welcome expressions of opinion regarding it.

Women Workers in Engine Shops Abroad

One of the lessons of the European War that is being emphasized is the fact that "mere man" is not such a big toad in the industrial puddle as he has for years assumed. According to the *Mechanical Engineer* (Manchester), B. H. Morgan, of the Technical Department of the Ministry of Munitions, stated in an address recently delivered at a meeting of the Manchester Engineers' Club, that nine hundred and fifty thousand women are employed in munition works, and do work from the heaviest unskilled operation to the highest grade of toolroom nonrepetition work.

It has been the accepted idea on this side of the water that the work of women abroad has been confined to certain unskilled processes, doing the same operation over and over again. As a matter of fact, according to Mr. Morgan, after a few months' shop experience women are today building the greater part of one of the best high-speed engines in the country; they are also building guns—not doing merely the roughing work, but finishing the finer work on the breech mechanism. Two years ago engineers would have scoffed at the assertion that women could build a marine engine, but today they are doing important work on this type of prime mover.

The apparatus that is of vital importance to the aviator is the engine; that must of necessity be not only well designed, but properly constructed. Mr. Morgan states that the aëro engine, a fine piece of mechanism and formerly considered a toolroom job, is in some shops being built in greater part by women workers, who are doing good work in regard to accuracy and output.

Although there are instances where the manufacturer has had difficulty in getting a normal output of production when a large percentage of women workers are employed, the ministry is taking steps to improve this condition by employing women officers to visit such shops, investigate the conditions under which the women are working and prescribe such remedies as are necessary to improve the organization of the works.

If women have become as proficient as Mr. Morgan states, the industrial situation after the war will require considerable readjustment and the returning soldier mechanic will find that a strong competitor has developed during his activities in the trenches.

It Is Quality That Counts

Never was power equipment of a superior quality at a reasonable price more in demand than at the present time. This assertion is borne out by the fact that there are numerous manufacturers in this country today who do not attempt to meet the prices of their competitors, but advertise and sell their products on a quality basis, and value received for the money invested.

Not so very long ago a manufacturer of a certain power-plant equipment advertised that its apparatus was the highest-priced of the kind on the market, but that the economies resulting from the installation of this equipment many times offset the additional cost over that of other types. On the proved superiority of its products the company is doing one of the largest businesses in its line today.

It is not only in the home markets that there is a demand for materials of high quality, but also in foreign markets. One product that has won out over European competition is American-made iron pipe, which has been mentioned in these columns before.

In a recent issue of the London *Electrical Review* is reproduced an article from the Melbourne *Age*, Australia, which sets forth at some length the indignation on the part of British firms in Victoria against the Australian Railway Commission for awarding a contract to an American firm for thirty miles of insulated cable for signal purposes, to the exclusion of the British bidders, at a much higher price than the latter were willing to supply it for. According to the narrative a representative of the British firms secured a sample of the American cable that had been in use for twenty years and sent it to England, where is was subjected to a rigid scrutiny, after which the English firms agreed to manufacture the same cable in every detail except the trade name, at a price much less than that asked for the American article. The British representative in Victoria of insulated-cable firms declared that the American article was quite ordinary. However, the commission points out that the department's policy is to give preference to home-made articles, but that there were cases where in the interests of the railways and state it was necessary to go outside to secure certain indispensable articles. In this particular instance the American article mentioned in the tender was the most durable for hard wear and use in damp places that was known, and it was only the great necessity for its use in a most important part of the railway system that prompted its purchase; and in using this wire they were doing the right thing, and any extra cost entailed in its purchase was amply made up for in its lasting qualities.

These statements certainly do not corroborate the assertion that the American article is quite ordinary. We are inclined to think that the commission's presentation of the facts is correct, for it does not seem possible that they would be so unpatriotic on the one hand and so foolish on the other as to pay a higher price for American goods than for British unless for good reasons. The foregoing is only further proof of what has been pointed out before, that American manufacturers are not always required to compete in prices in foreign markets if they can only prove the superiority of the American-made article and see to it that the goods do the work that they are sold for; or, in other words, it is quality that counts.

Unsuspected Heat Losses

Engineers and managers of power plants have been endeavoring to effect economies in every possible way on account of the unprecedented rise in the cost of coal. Every improved device that can be used in a boiler room to increase economy has been adopted, and striking improvements have been made in many plants. Generally, however, all attention has been directed to improved methods of burning the coal and to using the steam at best economy in the engines; but frequently little thought is given to losses that may occur between these two important parts of the plant—that is, losses in the steam piping from unnecessary radiation.

Often steam-pipe joints are not covered by insulating material, for many engineers hold that these must be accessible to tighten up or repack when leaks occur. A ten-inch extra-heavy pair of flanges with steam at one hundred and sixty pounds pressure and with an average boiler-room temperature of ninety degrees will radiate the equivalent to over a ton and a quarter of coal per year, if steam stays on the pipe for twenty-four hours each day. About a ton of coal can be saved by covering this carefully with two-inch asbestos blocks, cement and canvas; and at the present prices of coal, the saving in one year would pay for having the covering put on.

There are other exposed surfaces, such as the bonnets of valves, drips to traps, the bodies of traps themselves and the cylinders of duplex pumps, that could be covered to advantage. An inspection of the average plant will reveal quite a lot of such exposed surfaces even on the high-pressure piping. Moreover, insufficient thickness of covering is frequently an unsuspected source of heat loss.

These losses continue whether the plant is running or not, so long as steam is kept on the line. The sum total of all of them in many plants will amount to an appreciable percentage of the total coal burned, and the greater part of these losses can be easily prevented. It is therefore the duty of every responsible engineer, during these days of coal shortage and high prices, to assure himself that the losses from improper and insufficient pipe covering are reduced to a minimum.

⁂

As we go to press Congress has voted to uphold the recommendations of the President by declaring that a state of war exists between this country and Germany. The present struggle is essentially one of engineering organization and industrial resources, in which the production of power plays an important part; in fact, it is fundamental to the manufacture of all munitions and war supplies. Engineers of all classes will find opportunity for service; some with the armed forces, but the greater number in keeping the industrial wheels turning so that those at the front may be adequately supplied. In behalf of itself and its readers *Power* is proud to offer to the Government its unqualified support and any assistance that may be required.

⁂

It is proposed to raise twenty-five thousand dollars by public subscription to supplement the thirty-five thousand already appropriated by Congress for the erection of a monument commemorating the memory of John Ericsson. The time is most fitting to honor the memory of that eminent engineer who rendered such important service to the nation at a critical period in its history.

Correspondence

Mexican Oil in Diesel Engines

In *Power* for Mar. 20, 1917, on p. 400, Frederick Ewing, sales engineer for the Mexican Petroleum Co., is quoted as having said in an address delivered before the Providence Engineering Society, "Mexican oil is suitable for the Swedish and De La Vergne Diesels only."

After designing our experimental engine, and before it was definitely decided to place it on the market, we were obliged to demonstrate to the satisfaction of our executives in New York that we had developed an engine that would operate satisfactorily on asphalt-base crude oils such as are produced in large quantities in Mexico and California. It was realized that the market for an oil engine that could utilize only the relatively high-grade fuel oils or distillates would not be wide enough to justify the development and placing on the market of such a machine.

Ever since the Snow engine has been offered for sale, we have not hesitated to guarantee satisfactory operation on Mexican or California oils, provided the oils are thin enough to be handled by pumps; and in some installations it is necessary to preheat the oil in the main storage tank to secure the desired fluidity.

We will appreciate it if you will state in the columns of *Power* that the Snow horizontal Diesel type engine is also to be included among those that will operate on Mexican fuel oil. S. B. DAUGHERTY,

Chief Engineer Gas and Oil Engine Department,
Worthington Pump and Machinery Corp.,
Buffalo, N. Y. Snow-Holly Works.

[A letter from Mr. Ewing advises that in his statement as to the use of Mexican oil in Diesel engines he said: "The heavy Mexican oils are satisfactory for internal combustion engines, among which are the Swedish Diesel and De La Vergne engines."—Editor.]

Approves Long-Range Valve Gear

Mr. Hamkens in his article on "Releasing Gears" in the Mar. 6 issue of *Power* seems to give the long-range gear he illustrates in Fig. 150 unjust criticism.

Upon examining drawings of this release gear almost any person would say just what Mr. Hamkens said, that "the numerous levers, pins, links and rollers employed, which of course will wear out, make the valve gear noisy, require a lot of lubrication and attention and become generally troublesome"; but after having charge of a machine of this type for a while, the same person will discover that the reverse is true.

I am in charge of one of these machines that has been running ten to sixteen hours per day, six days per week, at 100 r.p.m. for the past fifteen years without a bit of machine work being done on it and without ever failing to hook on, and it makes no noise. The quantity of oil used and the attention given in excess of other types is so small it is not worth mentioning.

Instead of criticising the hardened tool-steel bushings and studs, I think the manufacturer should be commended for doing such work. This class of work seldom is found on a steam engine, but more often on a higher class of machine work, such as printing presses, etc.

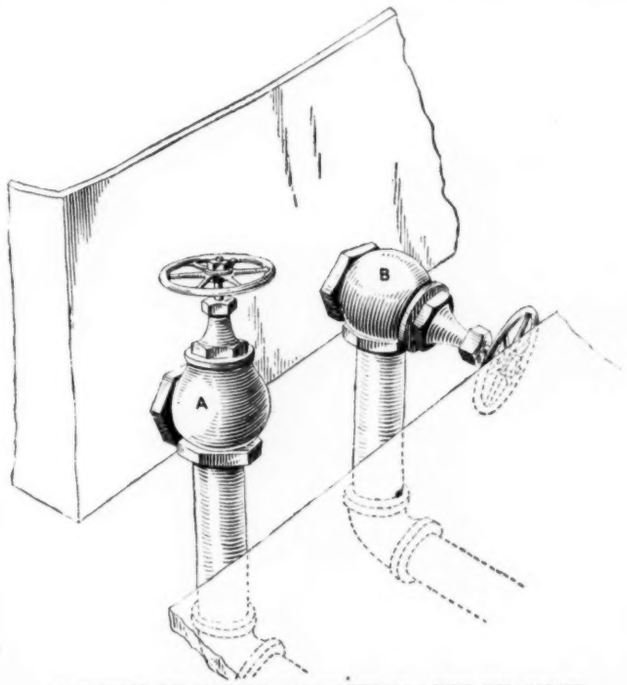
I also fail to see where Mr. Hamkens can find any measurable amount of "inertia due to the oscillation of the knock-off levers and connections," as they are all of such light weight.

There is one important feature he failed to mention; namely, the small spring provided between the knock-off lever and latch, which never operates unless the gear gets out of adjustment and is then intended to prevent a breakdown. L. B. CASE.

Hudson Falls, N. Y.

Locating Valves with Regard to Pressure

Valves controlling pressure and also those on pump suctions and intakes to surface condensers should be placed with regard to the pressure. I recently saw an angle valve at the tank on the suction to the boiler-feed



POSITION OF VALVE ON SUCTION LINE CHANGED

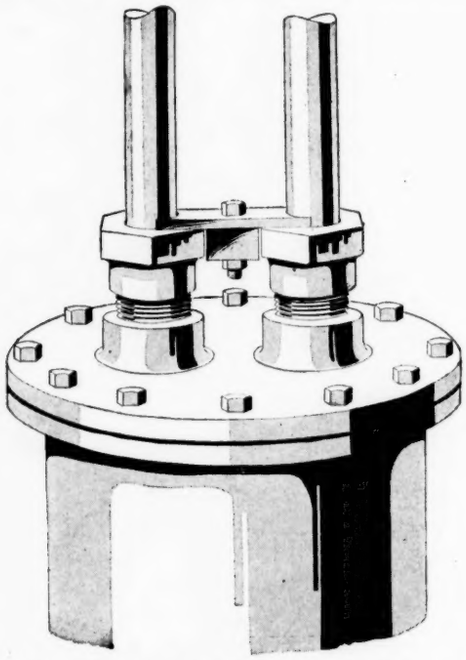
pump, located as shown at *A* in the illustration, it being the regular source of supply to the pump. I asked the engineer what would happen if the disk should get off the stem and close the valve. He said: "We'd be in a bad fix. I never thought of that happening. We could get water in a roundabout way, but it would be cold and it would take at least five minutes to make the shift of valves after the trouble was located," which probably meant burned boilers. At the best it meant a shutdown for the condenser and drains all discharged into this tank. Safety

would demand a change as shown at *B*, even if it did throw the wheel below the floor plates.

Concord, N. H. C. H. WILLEY.

A Packing-Gland Lock

It became necessary to tighten down the packing glands on the hydraulic elevators every day during the day's run, as they would begin to leak and it was evident that the gland nuts had become unscrewed while running. A set of nut locks were made, as shown, to keep them from turning. A piece of flat iron a little wider than the diameter of the rods was cut out half-round on each end and long enough to clear the rods by one-fourth



BLOCK BETWEEN GLAND NUTS PREVENTS SLACKING

of an inch, then a block of iron that would slide freely between the packing nuts when two faces were parallel was bolted to it. When the glands are tightened, the holders are dropped into place and prevent the nuts from turning. L. M. JOHNSON.

Emsworthy, Penn.

Removing the Ammonia Charge

On page 280 of the Feb. 27 issue there appears an article on "Removing Ammonia Charge," by E. W. Miller. The plan outlined by Mr. Miller is no doubt effective and, as he states, will enable the entire charge to be easily removed. However, there is the question of safety to be considered; and in my opinion an engineer should be careful about employing the method described, as there is always the possibility of an explosion where an air pressure is created in any part of an ammonia system while the charge or a part of the charge is present. This applies particularly to the condensing, or high-pressure, side of a refrigerating plant.

There is also the question of danger due to the presence of oil in the high-pressure oil trap and connections, which, when subjected to high air pressures and consequent temperatures, sometimes creates a condition that results in severe explosions.

The "safety-first rule" is a good one to observe in such cases, and only thoroughly experienced engineers should be intrusted with the execution of such a method as described by Mr. Miller. C. T. BAKER.

Jacksonville, Fla.

Condenser Efficiencies

On page 81 in the issue of Jan. 16, 1917, there appeared an article, "Condenser Efficiencies," which is not quite clear to me, particularly the first formula on page 82, for the water required to produce a given vacuum, and Fig. 5, showing the amount of condensing water required for different temperature rises with various amounts of steam condensed. It is questionable whether the formula itself is a correct statement of condenser performance. It is based on the supposition that the steam exhausting to the condenser is dry, whereas it is generally very wet, but may of course under certain circumstances be superheated.

A more convenient way of estimating the amount of condensing water is to consider the condenser as a heater and calculate the heat exchange from the exhaust to the cooling water, assuming that the radiation is negligible and that all the steam admitted to the engine is exhausted to the condenser.

The following computations will illustrate the method in which:

W_k = Pound of steam per kilowatt-hour.

Heat per pound of steam converted into work in the engine $= \frac{3415}{W_k}$ (1 kw.-hr. = 3415 B.t.u.).

W = Pound (total weight) of steam per hour.[1]

Q = Pound cooling water per hour;

H_1 = Total heat in 1 lb. steam supplied to the engine;

$T_2 - T_1$ = Rise in temperature of condensing water;

q_2 = Heat of liquid in condensate.

Heat rejected to the condenser per hour

$$= W\left(H_1 - q_2 - \frac{3415}{W_k}\right).$$

Heat taken up in cooling water $= Q(T_2 - T_1)$

$$W\left(H_1 - q_2 - \frac{3415}{W_k}\right) = Q(T_2 - T_1)$$

$$\frac{Q}{W} = \frac{\left(H_1 - q_2 - \frac{3415}{W_k}\right)}{(T_2 - T_1)}$$

The chart shows the application of the formula to general cases, and demonstrates that for a given temperature rise in condensing water the ratio of condensing water to steam is not constant for every case. For example, with 20 deg. temperature rise, the chart shows a range of ratios from 35 to 55, which is too great a variation not to be accounted for.

The formula as stated by Mr. Morgan is reasonably close for engines of a very high water rate—that is, low thermal efficiency—but results in large errors when used in connection with very efficient condensing engines or turbines. H. O'NEILL.

Larchmont, N. Y.

[1] In the previous article W was used to designate the weight of water to condense 1 lb. of steam, which is not its common use.—Editor.

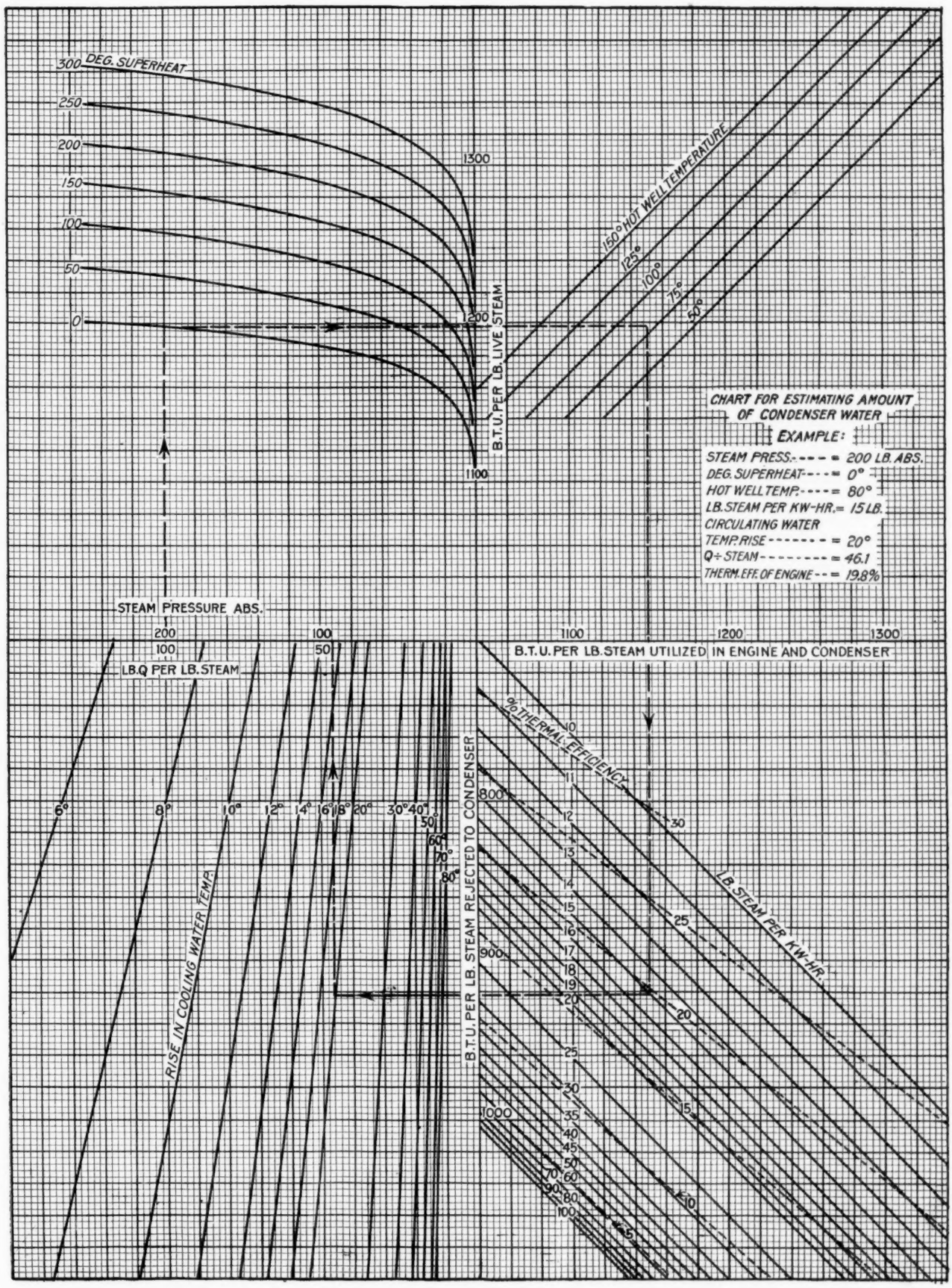
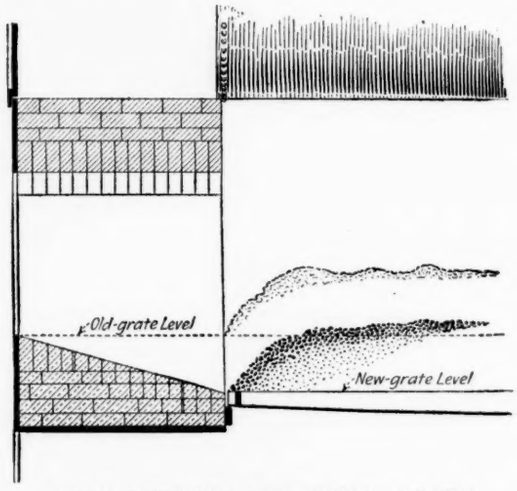


CHART FOR CALCULATIONS PERTAINING TO CONDENSER PERFORMANCE

Depressed Furnace Grates

I read with interest the description of the Budd depressed furnace grate in the Feb. 17 issue of *Power*. Besides the advantage of getting more space between the grate and the boiler shell, a grate set 6 to 8 in. below the fire-doors makes it more convenient for the firemen to keep a fire of even thickness without using fire tools to level the fuel.

In standard boiler settings for return-tubular boilers, the grates are about level with the fire-doors at the front end and the fire-door opening is about 16 in. high. With a soft-coal fire about 10 in. deep, which is good practice, there is an open space of only 6 in. above the fire bed and the top of the fire-door. This is not enough opening to



TWO POSITIONS OF FURNACE GRATE

get a good view over the fire surface. The result is that the fires are not kept at a uniform thickness, which permits an excess of cold air to be drawn in through the thinner spots in the fire bed. If the grates are lowered, say 6 in. below the fire-doors, there is, with a 10-in. fire bed, a free opening of 12 in. over the fuel, the firemen can see the entire surface of the fire bed, and the 12-in. space allows an unobstructed distribution of fresh fuel to all parts of the furnace. Thus the fire bed can be kept at an even thickness, which contributes to better combustion, less smoke and more steam per pound of coal burned.

I had the grates of a number of boilers lowered in the manner shown in the sketch, the full lines indicating the lowered grate and fire bed, and the dotted lines the original setting. FREDERICK KAISER.

Lansdale, Penn.

Care of Manhole Gaskets

I agree with Mr. Dale in the issue of Jan. 30, page 138 (see also page 330, Mar. 6), that gaskets can be used repeatedly with good results if proper care is taken in replacing them in the same position they were originally in.

I use flake graphite and oil, and I am never troubled with leaks. I have used the same gaskets for eleven months, and even then they did not leak, but got so hard I discontinued their use. We wash the boilers 26 times a year, besides opening them for the inspector twice or three times a year, so it would take 28 or 29 gaskets a year for each if used only once. We have four boilers rated at 150 hp., 120 lb. gage, and use the same kind of gaskets on all. A. F. BOLDUC.

Granby, Que., Canada.

Removing Scale from Between Headers

I would suggest, in reply to Mr. Williams' inquiry on page 296 in the issue of Feb. 27, that he try a compass saw or a keyhole saw for removing the scale from between the headers.

I have had no such experience, but have no doubt about the compass saw "delivering the goods." I would be pleased to see a report of the degree of success he may have with the suggestions offered, or if he finds a better way, it will help me to know of it.

St. Catharines, Ont., Canada. R. MCLAREN.

Collector-Ring Brushes Stuck

The writer had been having trouble with the inside collector ring of a motor-driven exciter all the evening, due to sparking. No amount of attention seemed to do it any good; instead of the sparking decreasing, it was increasing. As a last resort I decided to change the brushes on that ring. I was surprised to find that no more sparking was noticed after changing one of the brushes on that collector ring. At this time it was about midnight, the time to make the entry upon the station log of the various meter readings. On going to the switchboard gallery, it was evident that things were not all right. The following condition existed:

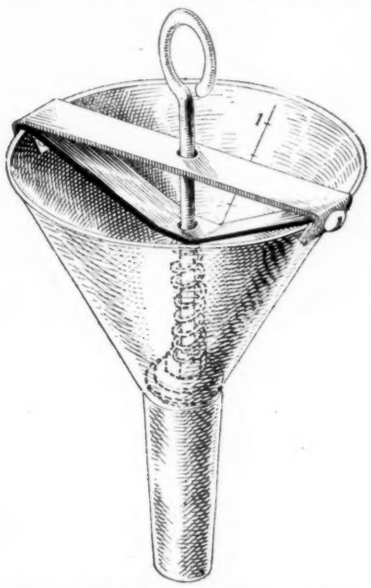
The exciter voltage was two-thirds above normal, the exciter amperes showed a like condition, the amperes on the meters of the synchronous motor for both field and stator were very high, and the generator ammeters showed that the machine was working at full capacity, although the wattmeter showed the normal load for this period. The voltage was normal; this was held so by the regulator which was sparking badly. There is no doubt that without the voltage regulator things would have been different in regard to the voltage being normal. There was no question that something was wrong, and I immediately decided that it was the motor-driven exciter. The turbo-exciter was started and put on the load, while the motor-driven exciter was shut down. Things at the switchboard immediately went back to normal, which made it apparent that I was on the right track. Going down stairs to the motor-driven exciter, the trouble was immediately apparent. The inside collector ring was burnt nearly a third of the way around the circumference. The ring was trued up by means of a file and emery cloth so that when the exciter set was put back in service there was no sparking and operation was normal again.

The reason that the sparking on that one ring stopped after one of the brushes had been replaced was as follows: The brushes were a trifle too large for the holder, and it was necessary before putting them in to round off the corners from the top down. When the brush was taken out, it was found that I had rounded off the corners only halfway up, with the result that it did not make proper contact. THOMAS M. GRAY.

Middletown, N. Y.

Combined Measure and Funnel

The combination shown in the illustration serves as a measure and a funnel as well. The marks for different quantities of course are found by once pouring in different measured amounts and marking the scale accordingly.



STOPPER IN BASE OF FUNNEL

The spring holds the stopper down to prevent the oil from flowing out. The construction may be simplified by using only the upper guide and a tight-fitting cork on the end of the rod.

L. V. LAUTHER.

West New York, N. J.

Point of Maximum Piston Velocity

There appeared in the correspondence columns of *Power,* issue of Mar. 6, 1917, an article by Wallace H. Martin, entitled, "Distribution of Inertia Effect," which was submitted as a correction to an article in the Nov. 14, 1916, issue, entitled, "Compression from a Mechanical Point of View."

The correction Mr. Martin supplied was badly needed and well presented with the exception of one statement, and I believe this statement is rather widely accepted by engineers generally. Mr. Martin says: "It is a well-known fact, which can be proved either analytically or graphically, that the velocity of the piston is a maximum when the crank and connecting-rod are at right angles."

I have seen this statement elsewhere, and there are textbooks which, in treating of piston velocity and acceleration, give this point as that of maximum velocity. However, this is not the point for maximum piston velocity, as I shall attempt to show. It is not far from the true point in engines with long connecting-rods and may be a considerable distance from the true point in those with short rods.

Perhaps the best way to prove my assertion is by the use of the theoretically accurate Klein construction for the determination of the force necessary to accelerate the reciprocating parts. If the velocity of the piston is a maximum when the crank and connecting-rod are at right angles, then the accelerating force at this point would be zero.

Fig. 1 represents the Klein construction for a ratio of connecting-rod to crank of 2 to 1, and crank and rod at right angles. The accelerating force, F, is given by the equation

$$F = \frac{W \times V^2}{g \times R} \times \frac{DC}{BC} \qquad (1)$$

where

W = Weight of reciprocating parts;
V = Crankpin velocity in feet per second;
g = 32.16;
R = Crank length in feet.

Or the same value for F at this point may be obtained from the accurate analytical expression,

$$F = \frac{W \times V^2}{g}\left[\frac{\cos^2 \phi}{R \cos^3 a} + \frac{\cos(\phi + a)}{C \cos a}\right] \qquad (2)$$

where

W = Weight of the reciprocating parts;
V = Velocity of the crankpin in feet per second;
g = 32.16;
R = Length of connecting-rod in feet;
C = Length of the crank in feet;
ϕ = Crank angle shown;
a = Connecting-rod angle shown.

Referring to equation (1) for the Klein construction, Fig. 1, DC would have to be zero if the piston velocity is maximum for this position of the crank. However, with the crank taken, 1.5 in. long, DC is about 0.21 in. long.[1]

Again, it can be shown that the velocity of the piston is not maximum when the crank and connecting-rod are at right angles by means of the velocity construction directly, Fig. 2.

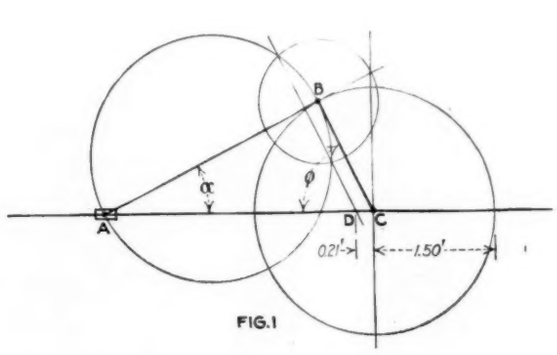


FIG. 1

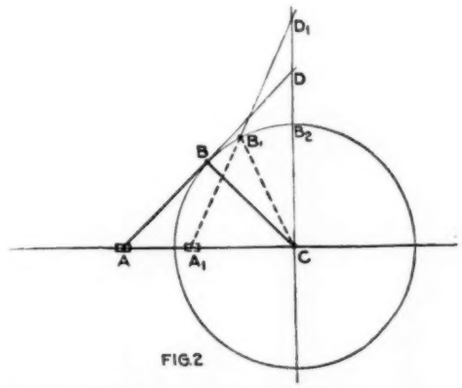


FIG. 2

GRAPHICAL DETERMINATION OF POINT OF MAXIMUM PISTON VELOCITY

[1]The drawings have been reduced in size, but the proportions are the same.—Editor.

For the purpose of illustration the ratio of the connecting-rod to the crank is taken at 1 to 1. In this construction if the length of the crank be taken to represent the crankpin velocity, then the intercept of the connecting-rod or the connecting-rod produced on the vertical to the line of the engine erected at the center of the shaft will represent the velocity of the piston (method of instant centers).

Referring to Fig. 2, it will be seen that with the crank and connecting-rod at right angles, crankpin at B, and the crankpin velocity represented by the length of the crank, CD represents to the same scale the piston velocity. For another position of the crankpin, such as B_1 between B and the 90-deg. position B_2 of the crankpin in its circle, the piston velocity is represented by CD_1, a greater velocity than that at the right-angle position B.

With this ratio of crank and connecting-rod the piston would not reach its maximum velocity until the crankpin had reached the 90-deg. position B_2 of its circle, and here the piston velocity would be infinitely great (theoretically).

Referring to Fig. 1, if V_P represents the piston velocity and V_C represents the crankpin velocity, then a correct analytical expression for the piston velocity is,

$$V_P = \frac{V_C \sin(\phi + a)}{\cos a} \quad \text{or} \quad V_P = V_C(\sin\phi + \cos\phi \tan a)$$

The following expression for the piston velocity eliminates the necessity of finding the connecting-rod angles corresponding to given crank angles:

$$V_P = V_C\left[\sin\phi + \frac{C \sin 2\phi}{2\sqrt{R^2 - C^2 \sin^2\phi}}\right]$$

where

C = The length of crank in feet;
R = The length of the connecting-rod in feet.

M. W. DAVIDSON,
Vermillion, S. D. University of South Dakota.

The Two Routes to Success

I was impressed with the foreword in the issue of Feb. 6, representing two young men—one as a toiler traveling the work road and the other as a student walking along the school way, and each path, though at first divergent, having the same goal—success—at the top of the hill, where the height of ambition lies, and I agree thoroughly with the caption—that success depends entirely on the "stuff in the man." Certain allowances, of course, must be made, for it is absurd to expect success if hopelessly handicapped. In other words, determination in a poor container cannot always succeed.

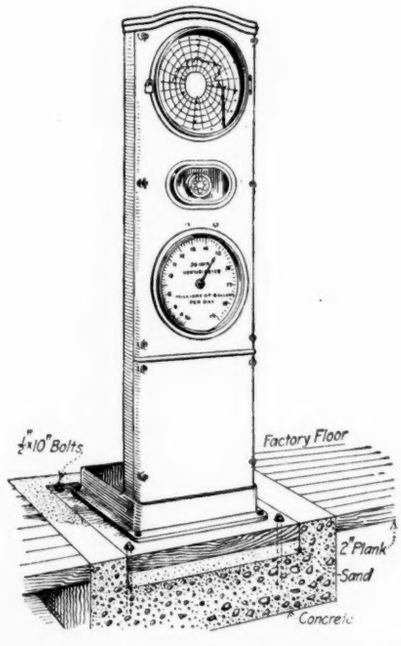
An engineering degree from a technical school does not represent success as an engineer—it means only that the student has completed certain studies which prepare him directly or indirectly for engineering work. He is not an engineer, but may become one by years of application. In the four-year technical course practically 2½ years are given up to the nonengineering subjects, and it is too much to expect to become an engineer in the remaining 1½ years; therefore success is achieved by the individual and not by a college education. On graduation, the student lacks detailed information—the information which his friend who has graduated from the fireroom has long since acquired—and the only way to secure this knowledge is to be willing to start at the beginning and to work in the shop or the power plant. The operating engineer, however, is short on technical information or the theory of the things with which he deals, and it is no small job to acquire this after a hard day's toil. Yet success—if success means more than the starting and stopping of engines—means that these things must be learned, and it is not an unsurmountably difficult problem provided one does not become dulled by lack of real mental effort. The operating engineer is in a school himself, because as the technical school has an atmosphere of technology, so has the engine room the atmosphere of engineering. Frequently, when I have been lecturing on machine and boiler design, the operating engineer has surprised me by his grasp of some phases of the subject.

So, to my mind, it is immaterial which road one takes—that through college or that through the engine room. Success is at the top of the hill, but only for the man who avoids "the path of least resistance," who by concentration of mind and effort overcomes the everyday obstacles in his path. H. J. MACINTIRE.

Seattle, Wash.

Eliminating Vibration of Meter

In setting up a recording venturi meter we found that owing to the vibration caused by the heavy mill machinery the meter clocks would not run and the pen arm vibrated so much that accurate records could not be obtained. To reduce the vibration we set it up as shown in the illustration. A concrete foundation for



SAND BED UNDER METER TO AVOID VIBRATION

the meter was put down with 2 in. clearance all around between it and the factory floor. On top of the concrete base we put a 2-in. bed of sharp sand and bolted a wooden block on top, and the meter was then fastened to the block. When the meter was set on this foundation, no vibration was noticeable and the records were clear and legible. J. H. HONEY.

Fajardo, Porto Rico.

Inquiries of General Interest

Advantage of Bronze Piston Rods for Hot-Water Pumps—For pumping hot water, why are brass piston rods better than iron ones? W. J. S.

With brass rods there is less roughening and unevenness of the surface from corrosion, especially when the pump is not in operation, and a tighter joint can be maintained by the rod packing.

Use of Dry Pipe To Improve Quality of Steam—We obtain wet steam from a 72-in. x 18-ft. return-tubular boiler when carrying the peak load. Would not a dry pipe placed in the boiler remedy the trouble? J. N. C.

Use of a dry pipe will improve the quality of the steam, but will not certainly remedy the trouble if the feed water contains organic matter or if the water level is carried too high.

Reason for Lap on Corliss Steam Valves—Why is lap put on the steam valves of a single-eccentric Corliss engine? F. C.

To secure early release and compression of the exhaust, it is necessary to advance the eccentric beyond its 90-deg. position. This makes all valve events earlier, and it becomes necessary to add lap to the steam valves, to prevent excessive lead and hold them closed until it is desirable to have the live steam admitted.

Lost Motion of Duplex-Pump Valve Gear—Why is lost motion necessary in the valve gear of the ordinary duplex steam pump? E. G. K.

The pump will not operate without lost motion or clearance between the valve rod and valve, or somewhere in the train of the valve-gear mechanism that will permit of a pause in the position of the steam valve, so it may stand open during continuance of the stroke.

Pounding of Engine from Reduction of Back Pressure—What causes an engine to pound when relieved of back pressure from exhaust-steam heating? D. S.

It is probable that when relieved of the back pressure from heating, the pounding results from obtaining less cushioning by compression of the exhaust of lower pressure. More cushioning effect can be secured by closing the exhaust valves earlier so as to obtain earlier compression.

Greater Clearance Required for Slide-Valve Engine—Why should a horizontal slide-valve engine have more clearance than a horizontal Corliss engine? F. G.

The exhaust passages and ports of a horizontal slide-valve engine usually are at the side or top of the cylinder, and water formed or finding its way in the cylinder is neither as readily nor as completely discharged during the exhaust stroke of the piston as in a horizontal Corliss engine, where the exhaust valves and passages are at the bottom of the cylinder. Hence more piston clearance is necessary in the slide-valve engine and this, together with the necessity of longer steam passages, results in a higher percentage of clearance space.

"Expansion" Valve of Refrigerating System—What office is performed by the "expansion" valve of an ammonia refrigerating system, and why is the valve so designated? E. E. M.

The so-called "expansion" valve is nothing more than a convenient mechanical device for regulating the amount of liquid ammonia passing to the expansion coil, by varying the opening through which the liquid flows. The liquid ammonia does not vaporize or expand until after it has passed beyond the valve, and the valve might more properly be called the expansion coil feed valve, rather than "expansion valve," which might erroneously signify that the liquid ammonia vaporizes or expands immediately when its pressure is relieved as it passes this regulating valve.

Induction-Motor Rotor Out of Magnetic Center—What effect have uneven air gaps between the rotor and stator of an induction motor upon its operation? In the case of a polyphase machine would uneven air gaps cause the current to be unbalanced in the different phases? M. C.

Unless there is considerable difference in the air gaps, the rotor's mechanical center being out of the stator's magnetic center should not have any effect upon the operation of the machine. Nevertheless, conditions may exist where the machine may turn free when dead, but when connected to the line the magnetic pull across the short air gap will be great enough to cause the rotor to strike the stator and prevent the machine from starting. The current should not be unbalanced enough to seriously affect the operation of the machine.

Isothermal and Adiabatic Expansion—What is the difference between isothermal and adiabatic expansion? L. B.

When a gas expands at a constant temperature, it is said to expand isothermally. To have a constant temperature during expansion the gas must be supplied with heat to take the place of heat converted into work. In a steam engine, heat may be supplied during expansion by means of a steam jacket around the working cylinder.

When a gas expands in a nonconducting cylinder, it is said to expand adiabatically, or with "no heat passing through," and its temperature will fall during the expansion, as no heat is supplied to take the place of that converted into work. The conditions for true adiabatic expansion probably are never realized in practice, but are closely approximated when the expansion takes place suddenly.

Equivalents of Heating to 70 Deg. F. in Zero Weather—What room temperatures should be attained with a direct-steam or hot-water heating apparatus with outdoor temperatures above zero to be equivalent to obtaining a temperature of 70 deg. F. in zero weather? H. L. D.

In his work on "Heating and Ventilating Buildings," Prof. R. C. Carpenter gives a table of equivalent temperatures for outside temperatures varying by 10 degrees from —10 to 100 deg. F., which is intended to be practically correct for hot-water radiation or steam at any pressure, all conditions such as wind and position of windows being the same. According to this table, attainment of a room temperature of 64.7 deg. F. with outside temperature of 10 deg. below zero, or 70 deg. F. in zero weather, would be equivalent to obtaining 75.1 deg. F. for weather at 10 deg. F.; 81 for 20 deg.; 86.5 for 30 deg.; 93.1 for 40 deg.; 98.7 for 50 deg.; 104.7 for 60 deg.; 110.5 for 70 deg.; 117.1 for 80 deg.; 123.5 for 90 deg.; 130.3 for 100 degrees.

Allowable Pressure for Furnace Sheet—What would be the allowable working pressure for the $\frac{7}{16}$-in. steel furnace sheet of a vertical fire-tube boiler where the furnace is 42-in. diameter with screwed and riveted stay-bolts pitched 7 x 8 in.? M. F.

According to the A. S. M. E. Boiler Code (par. 240), "A plain cylindrical furnace exceeding 38 in. in diameter shall be stayed in accordance with the rules governing flat surfaces" and (per par. 199) the maximum allowable working pressure for various thicknesses of braced and stayed flat plates and those that require staying as flat surfaces shall be calculated by the formula,

$$P = C \times \frac{t^2}{p^2}$$

where

P = Maximum allowable working pressure, pounds per square inch;

t = Thickness of plate in sixteenths of an inch;

p = Maximum pitch measured between straight lines passing through the centers of the stay-bolts in the different rows, which lines may be horizontal, vertical or inclined;

C = 112 for stays screwed through plates not over $\frac{7}{16}$ in. thick with ends riveted over.

As the maximum pitch of the stay-bolts would be 8 in., then for $\frac{7}{16}$-in. plate the maximum allowable working pressure would be

$$P = 112 \times \frac{7 \times 7}{8 \times 8} = 85.75 \text{ lb. per sq.in.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention—Editor.]

Effect of Current-Limiting Reactors on Turbo-Generator Systems*

By P. B. Juhnke

SYNOPSIS—An account of a cable breakdown near one of the generating stations of the Commonwealth Edison Company's system.

While current-limiting reactors are by no means of recent date, having long passed the experimental stage, comparatively few data are available showing in what manner they perform their intended functions under conditions of short-circuits on systems protected by them.

At 7:31 p.m., Dec. 29, 1916, a cable breakdown occurred on line No. 223 (see Fig. 5) at the Quarry Street Station of the Commonwealth Edison Co., Chicago, Ill. This system is one of the largest in the country and is amply protected by reactances. The first indications of trouble were the tremendous roar of the generators, the violent swinging of all tie-line and transmission-line ammeters, the automatic opening of the switches on a 5000-kw. frequency changer, which ties the 25- and 60-cycle systems together, and the automatic opening of lines 212, 213 and 226. After a period of about 10 to 15 seconds the automatic opening of line switch No. 223 cleared the trouble.

When the short-circuit had cleared itself, about 80,000 kw. of system load had been automatically disconnected by the operation of the protective devices in the substations. This

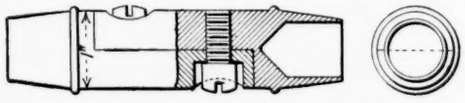


FIG. 1. CURRENT TRANSFORMER CONNECTOR

resulted in a rise of the system frequency, which caused three of the four Quarry Street generators to trip out on the steam end.

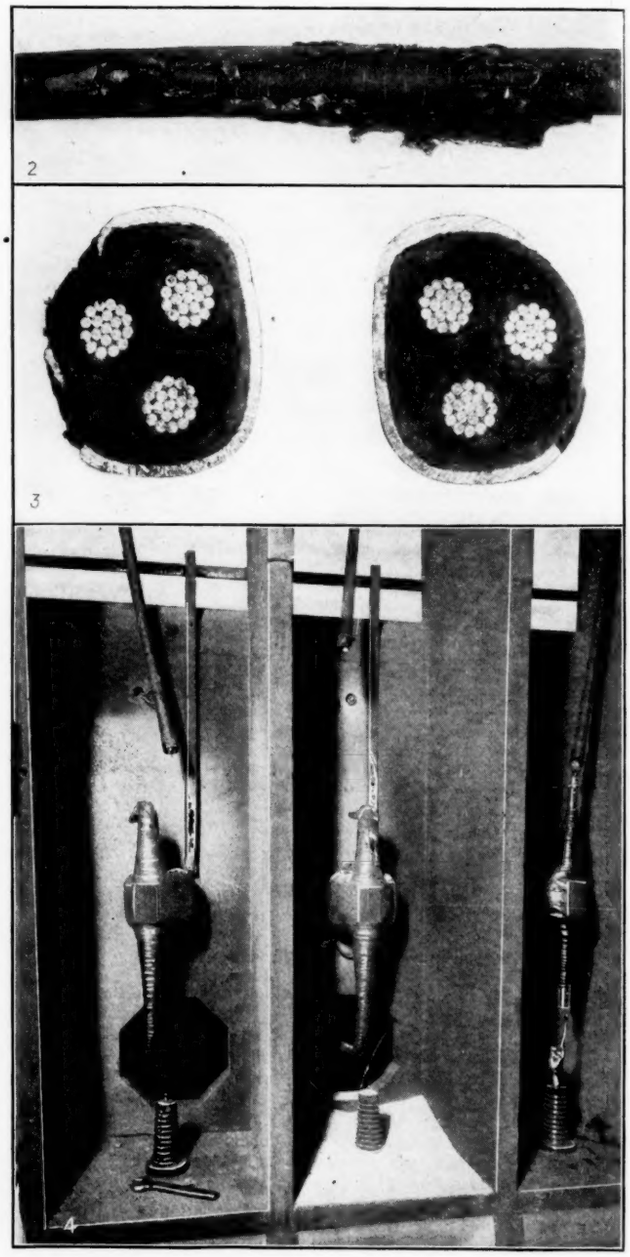
An investigation revealed the fact that the connector (Fig. 1) between the oil-switch leads and the current transformers on B and C phases on line No. 223 had burned off and that one of the leads had established an arc to a ground bus and the other to a bolt embedded in concrete. Fig. 4 shows the condition of the cables at the current transformers on line 223 after the burn-out. The arc damaged the relay wiring on B and C phases on line No. 223, making these two relays inoperative, but leaving A phase relay intact. A test on the cable of line No. 223 indicated that the line had burned open on B and C phases outside of the station, and that A phase was grounded. The cable fault was located in the conduit on the station grounds, approximately 600 ft. from the oil switch. About two feet of the cable was found to have been destroyed.

When repairs were made, it was found that this burn-out had occurred within a few feet of the location of a previous burn-out on line No. 1222 (see Fig. 5), which was in a diagonally adjacent duct. Nothing serious, however, was indicated by the latter burn-out. The switch had opened promptly, and the cable gave no evidence of any unusually severe trouble.

When repairs on line No. 223 were made and the close proximity between this burn-out and that on line No. 1222 was established, it was thought best to dig up the conduit, break out the ducts and expose the cable to determine if any other cables had been injured. On exposing the cable it was found that an adjacent duct wall had been broken and that the lead had been burned from one side of line No. 1217 (see Fig. 5) in the same duct. The force of the explosion had pushed the cable of this line forcibly against one side of the duct, so that the exterior of the former assumed very closely the form of the inside of the latter. This is shown in Fig. 3, which is reproduced from a photograph of a section of this cable after removal. The external injury of this cable at the location of the burn-out is shown in Fig. 2, as it was found eight days after the trouble on line No. 223 occurred, during which time it had been in continuous operation. This line did not break down, but the cable was removed and replaced.

An analysis of the trouble led to the conclusion that the initial fault on line No. 223 occurred between B and C phases in the cable. The lead sheath at the location of the fault being destroyed by the previous burn-out on line No. 1222, this was the most likely failure and probably due to moisture penetrating the insulation.

It is believed that when the fault outside was established, the great rush of current largely due to the nearness of the fault to the station bus caused the joint between the lead



FIGS. 2 TO 4. DAMAGE DONE BY SHORT-CIRCUIT

Fig. 2—Cable of line 1217 at point of burn-out. Fig. 3—Section of cable from line 1217. Fig. 4—Burned off line leads at current transformers

from the oil switch and the current transformer to break apart on both B and C phases. It is probable that when the arc to ground was established, the arc to the short-circuited cable was maintained until A phase broke down, either to ground or to one of the other phases, which caused the A phase relay to open the oil switch on line No. 223, thereby clearing the trouble from the duct.

*Abstract from a paper presented at the A. I. E. E. mid-winter convention, Feb. 14, 1917.

The total capacity of the 25-cycle 9000-volt system here concerned consisted of 17 generators and a 5000-kw. frequency changer of a combined capacity of 251,000 kw., each of the generators having, including its external reactance, a total reactance of approximately 8 per cent. The load carried was approximately 200,000 kw. The system at the time of the trouble consisted of four more or less distinct parts, with generating capacities and loads at the time of trouble as shown in Table I.

TABLE I. GENERATOR CAPACITIES AND LOADS

Station or Section	Generating Capacity	Number of Machines	Load
Northwest	50,000 kw.	2	50,000 kw.
Fisk A Section	60,000 kw.	5	48,000 kw.
Fisk B Section	80,000 kw.	6	55,000 kw.
Quarry Street	61,000 kw.	5	49,000 kw.
	251,000 kw.	18	202,000 kw

Fisk St. A and B sections are the two parts into which the Fisk St. Station 25-cycle bus is divided, each of these two sections being separately in parallel with Quarry St. over a tie-line protected by a balanced relay, consisting of three 250,000-cir.mil 3-conductor 9000-volt cables of an average length of 2400 ft. In each phase of this tie-line is a 20 per cent. series reactor, this value being based on the Y voltage drop at the rated full load of 10,000 kv.-a. per line. These three sections are thus operated on the open-ring principle. Northwest is connected with Fisk St. section B over four tie-lines of a total cross-section of 1,000,000 cir.mil, having an average length of eight miles, these tie-lines carrying stations along their route. The relays on these tie-lines are of the bellows type, with a setting on each line as follows: One minute, 9375 kv.-a.; two seconds, 11,700 kv.-a.; instantaneous, 14,000 kv.-a. Fig. 6 is a diagrammatic representation of the system as it existed at the time the trouble occurred. At this time the synchronous apparatus supplied by the different sections is given in Table II.

TABLE II. SYNCHRONOUS APPARATUS SUPPLIED BY DIFFERENT SECTIONS

Sections	Apparatus in Substations Synch. Conv.	Synch. Motors
Northwest	9 substations	2 substations
Fisk A Section	20 substations	3 substations
Fisk B Section	18 substations	1 substation
Quarry Street	15 substations	1 substation

At the time that the trouble occurred, nearly all the synchronous apparatus feeding from Quarry St. lines was automatically disconnected, about 70 per cent. through operation of alternating-current overload relays opening oil switches,

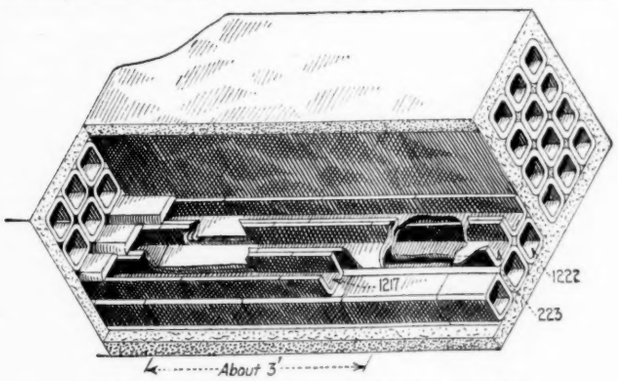


FIG. 5. SECTION OF EXPOSED DUCTS

apparently due to back feed into the short-circuit; about 28 per cent. due to reverse-current or low-voltage release relay, tripping direct-current circuit breakers. This ratio of apparatus disconnected by operation of oil switches to that disconnected by operation of direct-current circuit breakers, is exceedingly small in the stations supplied by either of the Fisk St. stations, while none of the apparatus on the Northwest line was disconnected on the alternating-current side. The only machine that was automatically disconnected on the alternating-current side on Fisk St. B section tripped out because it was operating in parallel on its direct-current end with a machine twice its size, feeding from Quarry St., due to the overload caused by the reversal of the latter, on which only the direct-current breakers opened. Fig. 7 is a diagram of generating capacity, load carried and load interrupted when trouble occurred.

This diagram clearly demonstrates the beneficial effect of current-limiting section or bus reactors on the stability of the apparatus on the sections protected by them. While very nearly 100 per cent. of the capacity in load supplied by the section on which the trouble occurred was affected only 36 per cent. of the load on Fisk Street Section A, and 27 per cent. on Fisk Street Section B was interrupted. Of the total Northwest load only about 6 per cent. was affected. The smallness of this latter figure undoubtedly is due to the considerable amount of tie-line resistance between Northwest and Fisk Street Section B. The rather considerable loss in load on Fisk Street A and B sections was mostly due to direct-current circuit breakers opening in some of the substations supplied by A and B sections, which in a large measure was caused by overload from the interruption of substations which had been supplied by the Quarry St. line.

Calculations to determine the dimensions of the short-circuit current and stresses due to them can only be approximate. The paper gives the details of how the summary of the results was derived, which are: The maximum effective

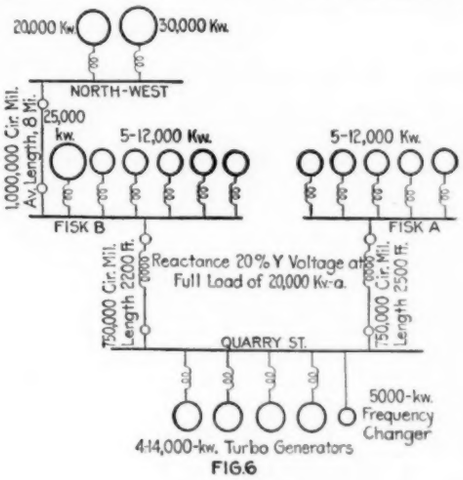


FIG. 6

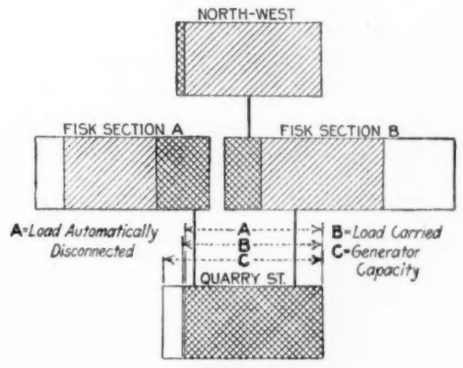


FIG. 7

FIGS. 6 AND 7. DIAGRAMMATIC REPRESENTATION OF THE SYSTEM AND LOAD

Fig. 6—Diagram of system as operated at time trouble occurred. Fig. 7—Diagram of generator capacity, load carried and automatically disconnected

short-circuit current into the fault from the various sources added vectorially equals 58,000 amp. at a power factor of 48 per cent., and the maximum effective value of the energy in the arc at a resistance of 0.025 ohms, equals 74,100 kilowatts.

It is of interest to compare the foregoing with the value of current that would have obtained under similar conditions had the system been without reactors in the generator leads and between sections of the bus. In this event the total short-circuit current computed in the same manner as with the reactors in circuit would have been approximately 106,000 amp., and the power factor 83 per cent. This would have multiplied the stresses incidental to the short-circuit as it occurred by 3.3, and would have given stresses of approximately 1140 lb. per ft. of parallel conductor below the oil switch. Such stresses more than likely would have damaged the above structure, would have immensely increased the task of the oil switches and made the service interruptions far more extensive and serious.

While synchronous apparatus in a number of substations was automatically disconnected through operation of either the alternating- or direct-current relays, the interruption in the substations so affected were of remarkably short duration, and the recovery was exceedingly rapid. As nearly as can be determined, the service interruptions from substations connected to the section in trouble amounted to 50,000 kw. for 5 min.—on one of the two sections affected by sectionalizing reactors to about 20,000 kw. for 3 min., and on the other to

about 10,000 kw. for 2 min. The behavior of the substation protective devices during the trouble is a subject full of interest, the complete analysis of which, however, had not been computed up to the time of writing this paper.

It is the author's conclusion that considering the results in their entirety the influence of reactors must be pronounced as exceedingly beneficial. Not a single piece of generating-station apparatus was disabled, as was almost invariably the case before the installation of current-limiting reactors. Even on the sections directly affected, everything was ready for immediate resumption of service as soon as the trouble was cleared. The value of the reactors seems to have been happily chosen. No evil results attended the operation of the system during and after the trouble. No oil switches failed, and, most important of all, comparatively little load was interrupted on the sections protected by the sectionalizing reactors.

Boston Engineers Hold Power-Plant Symposium

The first session of the power-plant symposium under the auspices of the Boston Sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers was held at the Engineers' Club, Boston, on Wednesday evening, Apr. 4. A buffet supper preceded the technical session, which was devoted to the general subject of "Recent Developments in Steam Generation." A. L. Williston acted as chairman and about two hundred were present.

The first paper of the evening was on "Developments in Fuel Oil vs. Coal," by Frederick Ewing, mechanical engineer for the Mexican Petroleum Co. This was followed by a paper on "Uptodate Stoker Practice," by Sanford Riley, of the Sanford Riley Stoker Co., Ltd. I. E. Moultrop, of the Edison Electric Illuminating Co., Boston, next discussed "High Pressures and Temperatures in a Modern Station," reviewing the work that is being done in some of our latest plants, particularly the River Station of the Buffalo General Electric Co. (see "Power," Feb. 13, 1917).

An interesting review of the recent work of Kreisinger, Ovitz and Augustine, of the Bureau of Mines, on combustion in the fuel beds of hand-fired boiler furnaces (see Technical Paper 137, Bureau of Mines) was given by Prof. L. S. Marks. These investigations showed that with a 6-in. fuel bed the oxygen in the air rising through the grate is all used up in combustion in the first four inches from the grate; at this point the carbon dioxide content of the gases has reached or passed a maximum of 10 to 16 per cent. and begins to drop. At the surface of the fuel bed the gases contain no oxygen, only 6 to 8 per cent. of carbon dioxide and 20 to 32 per cent. of combustible gases. The composition of the gases is practically independent of the rate of air supply. In general the temperature in the fuel bed is highest three to five inches from the grate.

P. A. Boeck discussed "High Temperature Insulation of Boiler Settings," in which he reviewed the subject as discussed by Joseph Harrington in "Power" of Mar. 27, 1917. Discussion was deferred until all the papers had been read.

The program for Thursday, covering "Isolated Plants and Central Stations" and "Developments of Prime Movers," will be reported in next week's issue.

Opportunities for Manufacturers and Investors in Chile

On Thursday afternoon, Mar. 29, in the Waldorf-Astoria, New York City, Hon. Jose A. del Campo F., commercial delegate of the Chilean government to the United States, delivered an address before the National Association of Manufacturers on "Chile as a Field for Manufacturers and Investors." During the address the speaker briefly outlined the opportunities afforded the American investor and manufacturer both in the development of the vast national resources and in the promotion of new industrial enterprises by his country.

Capital, said Señor del Campo, has been the only obstacle preventing Chile from carrying into practice all those projects which would mean for the investor as well as for the two countries concerned productive enterprises. The engineering achievement shown by the American railroad builders would solve the natural problems in crossing the Andes to connect Chile with Argentina.

Although several of the rivers of Chile are navigable and used for the conveyance of trade, the most important feature of the rivers throughout the country is the vast source of power that may be developed from their immense waterfalls

Chile, besides possessing a vast wealth in gold, silver and copper, has great deposits of iron, coal, manganese, cobalt, nickel, zinc, lead, wolfram and many other minerals, which have not as yet been exploited except superficially, on account of the lack of capital. A few years ago oil was discovered in Chile. Few people in the world are better able to realize the immense possibilities of such deposits when the necessary capital is available to develop them, than the American.

Although these mineral deposits would have placed Chile in line as one of the richest mineral producers in the world, nevertheless, without them she would always be in first rank among mineral nations on account of the large deposits of nitrate of soda, which are practically the only ones in the world. The world's annual consumption is estimated at 3,500,000 tons per year, yet these mighty deposits will be able to cover the necessity for at least 300 years. The quantity of nitrate already surveyed amounts to the astounding figures of 541,000,000 tons.

The Chilean government has recently announced the sale of several parcels of nitrate land; these sales are to open at noon Apr. 16, 1917. In the constitution of Chile foreigners are given the same right to acquire the parcels as the Chilean citizens.

Engineering Coöperation

On Mar. 29 and 30, in the quarters of the Western Society of Engineers, Chicago, the third conference of the Committee on Engineering Coöperation was held. Delegates were present from various engineering societies of Illinois and surrounding states, and the four large national associations were represented. Prof. F. H. Newell presided. Expressions from the various delegates showed what was being done in the way of coöperation in the surrounding states. F. G. Jonah read a paper on the Engineers' Club of St. Louis, which serves as an excellent example of how local coöperation may be obtained and of what the functions of an engineering organization should be. Cleveland's excellent engineering publicity work was again brought to the attention of the delegates, and reference was made to the recent coöperative work of various associations in the state. The efforts of Minnesota engineers in influencing legislation was given brief mention, as was the work being done in Wisconsin, Indiana, Michigan and Louisiana. W. L. Saunders, of New York, forwarded a paper on the "Engineering Civic Federation," a proposed engineering organization on the lines of the Chamber of Commerce of the United States, which represents business interests as a whole. This federation would have county organizations, the several county chairmen electing state counselors and the state counselors electing a president. Subjects relating to county or state interests would be considered by the respective local members. Matters of national importance would be considered by the entire organization, its opinion being expressed only through a referendum.

An interesting diversion was a talk by J. S. Dennis, president of the Canadian Society of Civil Engineers, on the war problems of Canadian engineers, supplementing to some extent a paper by Prof. C. H. McLeod on the present organization of engineers in Canada. P. Junkersfeld told what the American Institute of Electrical Engineers was doing for its members, John F. Hale spoke of the standards in ventilation provided by the American Society of Heating and Ventilating Engineers, and Calvin W. Rice was present to review the long-continued efforts of the American Society of Mechanical Engineers to secure coöperation. A resolution was passed requesting the large national societies, working in conjunction with the administration committee of the conference, to provide the machinery to carry on the work.

An administrative committee was authorized, with F. H. Newell as chairman, C. E. Drayer, secretary, and three others to be appointed by the chairman, to continue the work and call conferences at such times and place as may be found desirable.

The following declaration of principles passed by the conference will best express the lines along which the new movement may be expected to develop:

1. National Societies—As a preliminary to all efforts toward coöperation among existing engineering organizations there should be the expressed intent to assist in strengthening and unifying the work of the national engineering societies in the advancement of engineering knowledge and practice and the maintenance of high professional standards.

2. Local Organizations—The invigorating of local societies is fundamental because of the fact that while the great national societies are important in setting standards and in considering broad problems, yet local affairs make up at least nine-tenths of the vital problems of the engineers' life. In each locality where there may be a dozen or more engineers so situated as to be able to meet occasionally, there should be

formed, if not already existing, an engineering association embracing all professional engineers and others interested in engineering to discuss and act upon these vital problems.

3. Home Rule—Each local engineering society should be autonomous or self-governed, wholly free in its activities from any dictation or control by other associations or connections, fully adapted to local needs and conditions, and exemplifying in its activities the principle of complete home rule.

4. Welfare of Members—Each such local or self-governing unit in its organizations and activities should give full recognition to the fact that the majority of the membership necessarily consists of men not yet enjoying complete or independent professional status, but who in large part have had a college or technical training and who in time may become professional engineers in the full sense of the word. Because of this diverse character of members, the activities of the local society, while maintaining high professional standards, should be so planned as to meet the needs of the young men as well as the older and be directed toward the welfare of all classes of its members and through them of the public.

5. Ethics—Each local engineering society should adopt and frequently make application of a code of ethics prepared in accord with the standards established by the national organizations or approved by other professional bodies. It is recognized that while it is impossible to prevent all violation of such a code, yet eternal vigilance is the price of maintenance of high standards. The enforcement of such a code is essential to the well-being of the community at large as well as for the protection of professional men from the improper competition of unskilled or unscrupulous men tending to reduce the opportunity for effective service to individuals and to the public.

6. Civic Affairs—Each engineering society should devote time and thought to local civic, state and national affairs which influence engineering progress.

7. The Public Engineer—Engineering societies should give special attention to those members of the profession who are in public employment and should recognize the high ideals and performance of the public engineer, seeing to it that he is furnished sympathetic support in his efforts in the public service.

8. Publicity—Each independent association in coöperation with others in its vicinity should maintain a local system of diffusing information on engineering subjects such as may be embraced in the term proper publicity of the profession as a whole.

9. Employment—For the benefit of the great body of engineers there is needed the development of a scientifically planned and well-conducted system of employment to be operated in coöperation by all engineering associations.

10. Conferences—Conference of representatives from each engineering organization should be held, at which all matters such as those above noted and others of general interest should be discussed.

OBITUARY

Horace H. Nelson, of New York City, died Mar. 24, in his 68th year, after an illness of eight months. He was among the first engineers of New York City to obtain an operating license. He was a charter member of Phœnix Association, No. 24, N. A. S. E., and held office as its secretary continuously from its organization to the time of his death. Mr. Nelson was prominent in the transactions of Phœnix Association and always took an active part in its social events. He was widely known among operating engineers and will be missed by a host of old-time friends. The services were held on Tuesday evening, Mar. 27, at his late residence, 505 Ridgewood Ave., Brooklyn, and the interment was at Evergreen Cemetery the following afternoon. He is survived by a daughter and two sisters.

ENGINEERING AFFAIRS

The New York Section of the A. S. M. E. will hold a meeting on Apr. 10. Earle Buckingham will talk on "Standards of Business Success."

The Buffalo Section of the A. S. M. E. will hold a meeting on Apr. 14. "Educational Systems and Apprenticeship Systems" will be discussed.

The Combined Associations of the N. A. S. E. of Manhattan, Bronx and Queens, held their annual dinner and dance on Saturday, Mar. 31, at the Hotel Netherland, New York City. The occasion measured up to the usual high standard that has always characterized events of the combined associations. There were present about one hundred and fifty, including engineers, guests and ladies. At the close of the dinner Jack Armour told some amusing stories after which dancing was enjoyed.

New Jersey Association No. 1, N. A. S. E., held its thirty-fifth annual entertainment and dance on Mar. 30, at Columbia Hall, Greenville, N. J. A vaudeville performance of high grade was followed by dancing. The officers of the association are: John J. Calahan, president; Frank A. La Pointe, vice president; John J. Reddy, financial secretary; Dennis F. Bartley, recording secretary; August Krohne, treasurer; P. J. Supple, corresponding secretary; James J. Hughes, conductor; Allan Canning, doorkeeper.

American Institute of Steam Boiler Inspectors of New York City held its regular monthly meeting at the Engineering Societies Building on Friday evening, Mar. 30. J. A. Kinkead delivered a talk on the manufacture of iron and steel, which was thoroughly enjoyed. Messrs. C. H. Davis and J. H. McNeil were appointed delegates to represent the institute at the forthcoming annual dinner of the American Institute of Steam Boiler Inspectors of Boston. Messrs. M. Fogarty and J. H. McNeil informed the members of progress made at hearings of the Department of Labor, State Industrial Commission, Bureau of Industrial Code, on modification and additions to the present boiler code of the Department of Labor—whose jurisdiction extends over boilers used for factory purposes, as provided in Sections 91 and 124 of the State Labor Law. According to Section 91: "The provisions of this section shall not apply to cities in which boilers are regularly inspected by competent inspectors acting under the authority of local laws or ordinances" or "where a certificate is filed or shall have been previously filed with the state fire marshal by a duly authorized insurance company in conformity with the provisions of former Section 357 of the insurance law." For the purpose of receiving suggestions and recommendations the Bureau of Industrial Code has held a number of public hearings in various parts of the state, and further hearings will be held as follows: Rochester, Tuesday, Apr. 10, 10 a.m., Chamber of Commerce; Syracuse, Wednesday, Apr. 11, 10 a.m., City Hall; Utica, Thursday, Apr. 12, 9:30 a.m., Chamber of Commerce; Albany, Friday, Apr. 13, 10 a.m., Chamber of Commerce, Arkay Building; New York City, Tuesday, Apr. 17, 10 a.m., Bureau of Industrial Code, 230 Fifth Ave., Room 2015. Copies of the proposed rules, which include the present rules of the State Department of Labor and the A. S. M. E. Boiler Code applicable to new installations, can be had by applying to the Bureau of Industrial Code, 230 Fifth Ave., New York City.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

of Power, published weekly at New York, N. Y., for April 1, 1917.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and County aforesaid, personally appeared Chester W. Dibble, who, having been duly sworn according to law, deposes and says that he is the Assistant General Manager of the McGraw-Hill Publishing Co., Inc., Publishers of Power and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are:

Publisher, McGraw-Hill Publishing Company, Inc., 10th Ave. at 36th St., New York, N. Y.

Editor, Fred R. Low, 10th Ave. at 36th St., New York, N. Y.

Managing Editor, Alfred D. Blake, 10th Ave. at 36th St., New York, N. Y.

Business Manager, George E. Andrews, 10th Ave. at 36th St., New York, N. Y.

2. That the owners are:

McGraw-Hill Publishing Company, Inc., 10th Ave. at 36th St., New York, N. Y.

Owners of 1% or more of Stock Issued:

James H. McGraw, 239 W. 39th St., New York, N. Y.
Arthur J. Baldwin, 10th Ave. at 36th St., New York, N. Y.
Edward J. Mehren, 239 W. 39th St., New York, N. Y.
Fred R. Low, 10th Ave. at 36th St., New York, N. Y.
Fred S. Weatherby, 1600 Beacon St., Brookline, Mass.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent. or more of total amount of bonds, mortgages or other securities are: Bondholders, James H. McGraw, Arthur J. Baldwin, Henry W. Blake, Imogene Whittlesey, Hugh M. Wilson, Fred R. Low, Fred S. Weatherby, John McGhie, G. Eugene Sly, Estate of John A. Hill.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest direct or indirect in the said stock, bonds or other securities than as so stated by him.

CHESTER W. DIBBLE,
Assistant General Manager, McGraw-Hill Publishing Co., Inc.

Sworn to and subscribed before me, this 31st day of March, 1917.

[Seal.] PHILIP S. HILL.
(My commission expires March 30, 1918.)

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Apr. 7, 1917	One Year Ago	Apr. 7, 1917	One Year Ago
Buckwheat	$3.40@4.40	$3.05@3.20	$6.50@6.75	$3.25@3.50
Rice	.....	2.50@2.65	5.50@5.75	2.70@2.95
Boiler	2.75@3.75	.....	4.25@4.50	.....
Barley	2.65@3.65	2.20@2.35	4.15@4.40	2.35@2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Apr. 7, 1917	One Year Ago	Apr. 7, 1917	One Year Ago
Clearfields	$4.50@5.25	$1.35@1.75	$8.00@8.75	$4.25@5.00
Cambrias and Somersets	4.90@5.50	1.55@2.00	8.50@9.00	4.60@5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $5.75@6, as compared with $2.75@2.85 a year ago; on cars Boston price is $10@10.50.
*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Apr. 7, 1917	One Year Ago	Apr. 7, 1917	One Year Ago
Buckwheat	$2.75	$2.75	$4.00@4.25	$3.00@3.25
Rice	2.20	2.25	3.50@3.75	2.15@2.25
Barley	1.95	1.75	2.65@3.00	2.00@2.10

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$6.25@6.75	$6.25@6.75	$4.50@4.75
South Forks	7.00@7.50	.....	5.25@5.75
Nanty Glo	6.75@7.25	.....	5.00@5.25
Somerset	6.50@6.75	6.50@6.75	4.75@5.00
Quehamoning	6.75@7.00	6.75@7.00	5.25@5.50

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Apr. 7, 1917	One Year Ago	Apr. 7, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3.40	$2.30
Rice	2.00	.90	3.00	1.80
Boiler	1.80	....	2.90	....
Barley	1.50	.55	1.75	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Apr. 7, 1917	One Year Ago
Slack	$3.25@3.50	$1.10@1.15
Mine-run	3.25@3.50	1.15@1.25
¾-in.	3.25@3.50	1.25@1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam Lump	.....	.....	$5.00	$2.75@3.00	$2.75@3.00
Lump	$3.75@4.00	$3.75	5.00	3.00@3.25	3.25@3.50
Egg	3.75@4.00	3.75	5.00	2.75@3.00	3.00@3.25
Nut	.....	3.50@3.75	.....	2.75@3.00	2.75@3.25
No. 1 nut	3.75@4.00	.....	.....	.....	.....
No. 2 nut	3.50@3.75	.....	.....	.....	.....
No. 3 nut	3.50@3.75	.....	.....	.....	.....
No. 1 washed	3.50@3.75	.....	.....	.....	.....
No. 2 washed	3.50@3.75	.....	.....	.....	.....
Mine-run	3.00@3.25	2.75@3.25	4.50@4.75	2.00@2.25	2.00@2.25
Screenings	2.75@3.00	2.75@3.00	.....	2.00@2.25	2.00@2.25

Hocking lump, $4.00@4.25; splint lump, $4.25.

St. Louis—Price per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Apr. 7, 1917	One Year Ago	Apr. 7, 1917	One Year Ago	Apr. 7, 1917	One Year Ago
6-in. lump	$1.65@2.00	$1.25@1.50	$1.75	$1.25@1.40	$1.15@1.25	$1.00@1.15
2-in. lump	1.65@2.00	1.20@1.40	1.75	1.15@1.25	1.00@1.10	.80@1.00
Steam egg	1.65@2.00	1.20@1.40	1.75	1.15@1.25	1.00@1.10	.80@1.00
Mine-run	1.65@2.00	1.05@1.15	1.50	1.05@1.10	1.00@1.10	.80@ .90
No. 1 nut	1.65@2.00	1.20@1.45	1.50	1.15@1.25	1.00@1.10	.75@1.00
2-in screen	1.50@1.75	.80@ .90	1.50	.75@ .90	1.00@1.10	.80@ .90
No. 5 washed	1.50@1.75	.80@ .90	1.50	.80@ .90	1.00@1.10	.75@ .80

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.
Low prices are caused by restrictions on cars. Outside country prices are from 25c. to 50c. higher.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.25@3.50	Carbon Hill	$2.75@3.25
Big Seam	2.75@3.00	Cahaba	3.25@3.50
Black Creek	3.25@3.50		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ark., Bearden—The Bearden Electric Light Co. has been granted a franchise to construct and operate an electric-light plant in the city.

Ark., McGehee—City plans to make improvements to the electric-light plant, including the remodeling of the power station, the installation of an additional 120-hp. Diesel engine, 1—100-kw. General Electric alternator with necessary switchboard apparatus, etc. H. W. Wright, Mgr.

B. C., New Westminster—The Brunett Saw Mills Co. will construct a boiler house.

Calif., Fresno—The San Joaquin Light and Power Co. will construct a substation at Jensen and Cornelia St. Estimated cost, $15,000. G. O. Newman, Los Angeles, Ch. Engr.

Calif., Wasco—The San Joaquin Light and Power Corp. is having plans and estimates prepared for a lighting system. G. O. Newman, Los Angeles, Ch. Engr.

Fla., Fellsmere—The City Comrs. are considering installing an electric-light plant and will equip it with a 50-hp. oil engine and generator.

Fla., New Port Richley—City is considering plans for the installation of an electric-light plant. G. R. Sims, Port Richley Co., is reported to be interested.

Ill., Anchor—E. Riecks is reported to be interested in the organization of a company to be known as the Anchor Electric Light Co. to build an electric-light plant.

Ill., Metropolis—City voted bonds to extend and improve electric light in the city.

Ind., Stroh—The Stroh Cement Co. is reported to be interested in a project to install an electric-light plant in the city.

Kan., Baldwin—City election in April to vote on bonds for rebuilding electric-light plant in the city.

Md., Baltimore—(Westport)—The Consolidated Gas, Electric Light and Power Co., Tepington and Liberty St., plans to construct a generating station at Westport, to be known as station "C" and will be equipped with 6—1047-hp. boilers and will resemble stations "A" and "B" in design and construction. Estimated cost, $500,000. A. Banks, Jr., Pur. Agt.

Minn., St. Vincent—J. Kneeshaw is planning to install an electric-light plant at his farms.

Mo., South St. Louis—(St. Louis post office)—The Union Electric Light and Power Co. plans to construct a substation at Broadway and Osage St. with an ultimate capacity of 15,000 kw. and will receive electricity at 13,200 volts from Ashley St. plant which it will step down to 2400 volts for distribution. The company will build a high-tension transmission line from the new station to Continental, 3 mi. distant, and to Festusa, distance of 30 mi. Space will also be provided for street-lighting equipment in the substation. Estimated cost, $200,000.

Mont., Poplar—The City Council plans to hold a special election to vote on the proposal to grant a franchise to install an electric-lighting system in the city.

N. M., Hanover—The Hanover Bessemer Iron and Copper Co. will rebuild its power plant recently destroyed by fire.

N. Y., Akron—The State Legislature has passed a bill authorizing a $19,000 bond issue to install an electric-light plant and street-lighting system.

N. Y., Lackawack—City is considering the installation of an electric-light plant. J. S. Shields is said to be interested.

Ohio, Akron—Dir. Pub. Ser. receiving bids Apr. 18 for furnishing turbo-centrifugal pumps as follows: Item 1—High lift unit; 1 horizontal steam turbine reduction gear-driven centrifugal pumping unit complete with water-works type condenser and auxiliaries, normal capacity of 10,000,000 gal. daily capacity against a total head of 220 ft.; Item 2—Low lift unit; 1 horizontal steam turbine reduction gear-driven centrifugal pumping unit, normal capacity of 25,000,000 gal. daily against a total head of 12 ft. Foundations will be furnished by the city. G. G. Dixon, Engineering Dept., Water-Works Office, 102 East Mill St., Akron, Engr.

Ohio, Cincinnati—The Union Distilling Co. will construct a brick addition to its boiler house on Carthage Pike. Estimated cost, $25,000.

Ohio, Dillonvale—The Sunnyside Electric Co. plans extending its electric transmission line from Dillonvale to Amsterdam, about 25 mi.

Ohio, Marion—The Fairbanks Steam Shovel Co. will install a power plant to be equipped with a 1000-hp. engine and an 800-kw. generator.

Okla., Covington—The City Trustees have granted a franchise for an electric-light plant in Covington.

Penn., Sharon—The Shenango Valley Electric Light Co., 63-65 State St., will construct an addition to its substation on Silver St. C. O. Bailey, Youngstown, Pur. Agt.

S. C., Fountain Inn—City has retained J. N. Ambler, Winston-Salem, to prepare plans for an electric-light plant.

S. D., Marvin—City plans to install an electric-lighting system.

Utah, Salt Lake City—The Utah Power and Light Co., Kearns Bdg., is having surveys made for an addition to its transmission line between Salt Lake City and Grace, about 130 mi. Estimated cost, $300,000. M. Cheever, Sat Lake City, Engr.

Wis., Clintonville—The Water and Light Comn. has had plans prepared for a 1-story, 40 x 60-ft. boiler house. G. C. Stewart, Supt.

Wis., Wonewoc—Wonewoc Power Engineering Co., 51 Corn Exchange, Minneapolis, is considering building a hydro-electric plant, including repairs to gates at dam, a power house, 50-kv.-a. generator and an auxiliary plant equipped with internal combustion engine.